THE UNIVERSITY OF ALBERTA

SOME EFFECTS OF PROGRAMMED INSTRUCTION ON GRADE EIGHT LANGUAGE

by

ARTHUR HOWARD ELLIOTT

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF EDUCATION

DEPARTMENT OF EDUCATIONAL ADMINISTRATION

EDMONTON, ALBERTA

October, 1963

1964

ABSTRACT

The object of this study was to determine whether the achievement level of students in a specified subject area might be raised through the use of an auto-instructional device - namely a programmed text-book. The experiment was based upon the performance of 91 students in grade eight in a town school. Of these, 46 were classed as experimental while the remaining 45 made up the control group. The 46 experimental subjects were selected by means of a table of random numbers.

On April 11, 1963, the California Achievement test in Language, Junior High Level, 1957 edition, Form W was administered to all students in each of the groups. On April 25, the experimental group commenced working on the programmed text-book, English 2600 by Blumenthal. Thirty school days later, June 7, 1963, the alternate Form X of the California Achievement Test was administered to both groups.

Time spent by experimental subjects on the program varied from twelve to twenty-one hours, with the mode time being fourteen hours; meanwhile the control subjects worked at unrelated assignments. Both groups continued with regular language instruction throughout the experimental period.

The results of analysis of the data showed that there was a significant difference between the mean gain scores (total) of the

two groups. When t-tests of significance were applied to the scores on the sub-tests, results were as follows:

Capitalization	- difference significant.
Punctuation	- difference not significant.
Word Usage	- difference significant.
Spelling	- difference not significant.
Total Test	- difference significant.

Further comparisons were made between I.Q. and mean gain score using the Pearson product-moment coefficient and Spearman's coefficient of rank correlation.

A final comparison was made between the mean gain scores of each of the groups on the whole test. These were referred to the California Achievement Test Grade Placement Table. The experimental group, which had had additional instruction time, (15 hours) advanced six months on this table while the control group, which had spent the standard amount of time in regular language classes, advanced an expected two months.

The study revealed that students do learn the mechanics of English by means of programmed instruction and that the amount of learning is appreciable.

ACKNOWLEDGEMENTS

The writer wishes to express sincere appreciation to Dr. G. L. Mowat for supervising this study and for the invaluable criticisms and suggestions; to Dr. John Andrews for constructive criticism and suggestions regarding statistical treatment; to Mr. S. A. Earl for helpful advice in regard to the final organization of the study; and to the Guidance Counsellor and teachers of the Fort Saskatchewan Junior High School for their part in supervising the gathering of data for this experiment.

TABLE OF CONTENTS

CHAPTER		PAGE
I.	INTRODUCTION	1
	Statement of the Problem	1
	Importance of the Study	2
	Delineation of Problem Scope	4
	Definition of Terms	4
II.	REVIEW OF THE LITERATURE	7
	The Basis of Programmed Instruction	7
	Reinforcement Theory	7
	Factors in Learning Efficiency	9
	A Systematic Approach to Instruction	10
	Consensus re Learning Theory	11
	The Nature of Programmed Instruction	12
	Teaching Machines	12
	The Two Types of Programming	17
	Related Studies and Research	19
	The I.B.M. Centre Teaching Machine Project	19
	Some Experimental Results in Schools	21
	College Level Research	23
	A Related Project	25
III.	THEORETICAL FRAMEWORK, HYPOTHESES AND EXPERIMENTAL DESIGN	26
	Theoretical Framework	26

CHAPTER PAGE

Supporting Theory 26

Reinforcement 26

Immediate knowledge of results 26

The accretion of learning through small steps . 27

Individual differences of students 27

The child learns by doing 27

Programmed instruction is valuable in research . 28

Criticism 28

Specific Hypotheses 30

Experimental Design 30

The Test Sample 30

The English 2600 Program 36

The Testing Instrument 38

Experimental Procedure 40

IV. COLLECTION AND TREATMENT OF DATA 42

Time Factors 42

The Null Hypothesis 42

Tests of Significance 43

Data for t-tests Applied to Gain Scores in
Capitalization, Punctuation, Word Usage,
Spelling and Total Test 44

Data Treatment - Capitalization 49

Data Treatment - Punctuation 54

CHAPTER PAGE

Data Treatment - Word Usage 59

Data Treatment - Spelling 64

Data Treatment - Entire Language Test 69

Comparison of I.Q. and Gain Score 70

Treatment of Scores of Students having an I.Q. above the Median for their Group 75

Comparison of Scores of Students having an I.Q. below the Median for their Group 76

The Pearson Product-Moment Correlation Coefficient Comparing Mean Gain Score and I.Q. 79

Comparison of Gain Score and I.Q. using Spearman's Coefficient of Rank Correlation. 82

Testing the Significance of Spearman's 82

V. CONCLUSIONS, RECOMMENDATIONS AND SUMMARY 84

Conclusions 84

A Review of the Findings 84

Implications for the Administrator 87

Implications for the Teacher 90

Recommendations 91

Summary 93

BIBLIOGRAPHY 96

LIST OF TABLES

TABLE PAGE

I. Total Score and Squared Deviations for Experimental Subjects on California Achievement Test in Language, Form W (Pre-test) 32

II. Total Score and Squared Deviations for Control Subjects on California Achievement Test in Language (Pre-test) 34

III. Comparison of Scores of Experimental and Control Groups on the Pre-test 36

IV. Programmed Instruction - Experimental Group Capitalization Test Scores 45

V. Programmed Instruction - Control Group Capitalization Test Scores 47

VI. Programmed Instruction Experimental Group Punctuation Test Scores 50

VII. Programmed Instruction Control Group Punctuation Test Scores 52

VIII. Programmed Instruction Experimental Group Word Usage Test Scores 55

IX. Programmed Instruction Control Group Word Usage Test Scores 57

X. Programmed Instruction Experimental Group Spelling Test Scores 60

TABLE PAGE

XI. Programmed Instruction Control Group
Spelling Test Scores 62

XII; Programmed Instruction Experimental Group
Total Language Score 65

XIII. Programmed Instruction Control Group
Total Language Score 67

XIV. I.Q., Gain Score and Squared Deviations for
Experimental Group 71

XV. I.Q. Gain Score and Squared Deviations for
Control Group 73

XVI. Pearson Product Moment Correlation Coefficient Data
for Experimental Group 77

XVII. Spearman's Coefficient of Rank Correlation Data for
Experimental Group 80

XVIII. Analysis of Gain Score in Terms of Grade Placement
Norms (California Achievement Test). 83

CHAPTER I

INTRODUCTION

Statement of the Problem

This study was designed to investigate the value of programmed instruction when used in a specific subject area. Experimental and control groups were set up, both of which continued with regular classroom instruction during the experimental period; the experimental group had programmed instruction in addition. The subject area selected was English language at the grade eight level. It was decided to investigate the several branches of language instruction which are measured by the testing instrument, namely, the California Achievement Test in Language, Junior High Level. This test has four sections: capitalization, punctuation, usage and spelling. It was determined whether there was a significant change in achievement in each of these four areas. A comparison was made between those students in the upper half of the class in regard to I.Q. with those in the lower half; it was determined which of these groups achieved the greater gain score and whether this gain score was significant. Further, it was shown whether there was a significant correlation between I.Q. and gain score achieved by students in the experimental group. The determinants used were the Pearson product-moment correlation coefficient and Spearman's rank correlation coefficient.

Finally, mean gain scores for each of the groups were referred to the grade placement table accompanying the California Achievement Test. This gave an indication of relative progress of the two groups during the experimental period.

Importance of the Study

Programmed instruction and the "Teaching Machine" have recently become major topics for consideration by educators. There are a number of reasons for this.

The "population explosion" of the post World War II period will have a great impact upon all educational systems. The resources needed to provide teachers and school facilities are limited and in some parts of the world almost entirely lacking. This problem in many of the under-developed countries is acute indeed, with the result that hundreds of millions of people to-day are growing up in illiteracy. It may well be that educational aid to these countries is more important than economic aid because, with education, the people will become more self sufficient and productive. Furthermore, much of the economic aid that is provided consists of complex tools and equipment. These must be fully understood if they are to yield their maximum usefulness and be maintained for enduring use. Thus, if we are to help the peoples of the under-developed countries, our material gifts must be accompanied by idea-giving as well.

The population explosion is just one of the problems taxing our educational facilities; another factor is the unprecedented rate at

which new knowledge is being developed. This is true particularly in the field of science. New means must be discovered for disseminating this knowledge as an adjunct to our present educational procedures.

In the field of technology, too, there is a growing concern as to-day vocations change almost completely in the span of one man's working years; thus, there is the problem of the technician who wishes to keep abreast of new developments in his field. He may find it difficult to ask for a leave of absence to take refresher courses, and therefore a well prepared program could provide in-service training for such a person.

Probably one of the most important aspects of this particular study is to investigate the usefulness of programmed instruction when it is used by the well trained teacher. He may wish to use it in several ways: (1) to insure that all students have acquired certain basic mechanical learnings necessary before more advanced instruction in the field is introduced, (2) to help slow learners or students who have been absent when a certain body of educational material was presented, (3) to provide enrichment material for more capable students, (4) to provide a vehicle whereby the classroom teacher can experiment with various methods of presentation of material and in this way conduct his own educational research. All such potential benefits are contingent upon the degree of learning which may be accomplished through the use of programmed materials. This study will, it is hoped, add to the knowledge regarding the efficiency of programmed instruction.

Delineation of Problem Scope

This experiment was carried out with a group of ninety-one students in grade eight in a town school. It is quite conceivable that if it had been conducted at another grade level or in another locale the results would not have been the same as those recorded here. The subject area investigated was English language. It would be erroneous to conclude that one would obtain the same results in another subject field.

Definition of Terms

The program consists of the subject matter to be taught arranged in a manner to facilitate instruction.

A frame is a unit of the program which requires a response from the student. The information required to answer a given item is contained in that item, a preceding item or in both.

Pacing. In a linear program this involves having the learner proceed at a rate at which almost all of his responses are correct. In this way desired behaviour is reinforced.

Prompts are stimuli included in a program frame which increase the probability that a given response will occur.

Branching is a term applied to a particular type of program which has built-in alternate sequences. If a student makes one or more wrong responses in a certain learning area, he is taken through alternate steps in the program designed to remedy his lack of understanding through additional explanations. Similarly, if a student demonstrates

through a long series of correct responses that he has the required understanding of subject matter, he may be skipped forward over additional material on the same topic.

Covert Response. A non-active response to a question such as thinking of an answer without writing anything down, pressing any buttons, etc.

Cue is a term used interchangeably with prompt meaning any bit of information given to make it more likely that the learner will make the correct response.

Error Rate. This term refers either to the number of errors a student makes in completing a program or to the percentage of the students giving wrong responses to a specific item on the program. It has value as a criterion in determining revisions to the program.

Extinguishing. The process of forcing a student to unlearn a certain response or mode of behaviour by failing to reinforce it each time it is emitted or by reinforcing it negatively.

Extrinsic Programming. This is linear Skinnerian programming where the program sequence is unalterable and the same for all students.

Fading is the technique of gradually reducing cues so as to make the student less dependent upon the program for information, thus forcing him to think for himself.

Game-Playing Technique. A method of using programmed materials to increase student motivation (believed to have possibilities in assisting the slow learner).

Intrinsic Programming. A type of programming employing the branching technique where all possible sequences of item presentation are built into the program and controlled by the students responses rather than by any outside agency.

Item. The smallest single unit of a program.

Law of Recency. A basic concept of reinforcement theory stating the last response reinforced is the one that is learned. A corollary to this is that the more quickly a response is reinforced, the better it is learned.

Overt Response. A response that involves a physical activity on the part of the student such as button pressing or response writing.

Reinforcement. A basic concept of psychology of utmost importance to programmed learning theory. In order that a student retain a piece of information effectively, it must be reinforced by informing him that he is right.

Step. This is the space between one item and another in terms of the mental operations necessary to go on with the next item. Difference in step size is practically impossible to measure although a subject of much theoretical dispute.

Stimulus. An item in the program which evokes a response from the student.

Systems Approach. A method of device design. Beginning with a device of certain capabilities, other features may be added. An example would be the adding of audio stimuli to one which previously had only visual capability.

CHAPTER II

REVIEW OF THE LITERATURE

A commonly stated problem of educators is that of meeting the specific needs of the individual learner. The proponents of programmed instruction believe that they have discovered something which will help meet this problem. Consequently, the basis and nature of programmed instruction should now be considered.

I. THE BASIS OF PROGRAMMED INSTRUCTION

Reinforcement Theory

At the heart of any learning program lies the practice of what Skinner calls "reinforcement".[1] He states that when that consequence known as "reinforcement" has been arranged, the behaviour of an organism may be shaped as desired. This reinforcement theory has sprung from the laboratory observation of the behaviour of lower animals. Nevertheless, a projection of these conclusions into the field of human learning provides a new challenge for teachers and psychologists alike. Certain generalizations arise from the reinforcement theory and pertain to programmed learning:

---

[1] B. F. Skinner, "The Science of Learning and the Art of Teaching," Harvard Educational Review, Vol. 24, No. 2, Spring 1954.

1. An individual learns or changes the way he acts by observing the consequences of his actions.
2. Consequences that strengthen the likelihood of the repetition of an act are called reinforcements.
3. The more _quickly_ reinforcement follows the desired performance, the more likely the behaviour will be repeated.
4. The more often reinforcement occurs, the more likely the student will repeat the act.
5. Absence, even delay of reinforcement following an action, weakens the probability the act will be repeated.
6. Intermittent reinforcement of an act increases the length of time a student will persist at a task without further reinforcement.
7. The learning behaviour of a student can be developed or shaped gradually by differential reinforcement - that is by reinforcing those behaviours which should be repeated and by withholding reinforcement following the undesired acts.
8. In addition to making repetition of an act more probable, reinforcement increases a student's activity, quickens his pace and heightens his interest in learning. These may be called the motivational effects of re-inforcement.
9. A student's behaviour can be developed into a complex pattern by shaping the simple elements of the pattern and combining them into a chain-like sequence.

Thus the reinforcement theory provides a rational basis for believing that a complex body of learning may be broken up into small components. Thus the student may be taught to master a body of subject matter by reinforcing or not reinforcing his responses to successive steps depending upon the accuracy or inaccuracy of his replies. The act of not reinforcing an erroneous response is known as extinguishing. By the discriminating use of reinforcement and extinguishing, the learning program enhances the likelihood that correct responses will be repeated and incorrect responses eliminated. Besides shaping a student's behaviour, reinforcement should inspire him to be aware at all times that he is learning. Most important, reinforcement should help him regard his learning experience as enjoyable and thus should motivate him towards further learning.

Factors in Learning Efficiency

Although many of the factors which influence human learning have now been identified, it is somewhat surprising to note that little is known about how to promote efficient learning in practical situations.

Gagne and Boles state certain reasons for this discrepancy.

> First, much of the experimental research has been directed towards testing theoretical points which have little immediate practical application. The researcher typically is concerned with how the learning process functions and not with the question of how to implement learning.
>
> Second, laboratory studies frequently demonstrate the effect of some va riable influencing learning by providing conditions that lead to a decrement in performance. It is

> not altogether obvious that the conditions that facilitate learning can be safely inferred from such studies.
>
> Experimental studies of learning have tended to involve rather restricted stimulus material far removed from the kinds of material that are of importance practically. The learning tasks that have been most intensively studied by psychologists have been of an artificial "laboratory" variety; relatively little is known about learning in real life situations.[2]

A Systematic Approach to Instruction

Today, more than ever before, what is needed is an efficient method of instruction. In the past many new methods have been proposed but there has been no systematic way in which these could be checked one against the other. There has been a tendency in the past to treat symptoms rather than the basic problem. The concern has been with such side issues as, pupil-teacher ratio, lengthening of the school day or the school year, or providing the teacher with a bewildering array of so-called teaching aids. Perhaps it is time to have a closer look at the instruction itself rather than to be concerned with the supporting activities.

What is proposed in programmed instruction is the implementation of modern learning theory and the findings of current research by incorporating these in our instructional program.

---

[2] Robert M. Gagne and Robert C. Boles, "A Review of Factors in Learning Efficiency," Chapter I in Galanter, E. *Automatic Teaching: the State of the Art*. New York: John Wiley and Sons, 1959, pp. 13-14.

Stolurow states that

> Instruction ... is a process in which a teacher presents subject matter to a learner so that he responds to it in a way that enables the teacher to determine the next item of information to be presented. We define the primary objective of instruction as the modification of the learner's responses to satisfy the teacher's criteria. In other words, the teaching-learning process can be viewed as communication and control taking place between the components of a system. In this case, the system is composed of a teacher, a program of instruction and a student, all in a particular pattern of interaction.
>
> Typically the teacher is the source of the communication and the controlling mechanism. However, he is ordinarily working with a group of students and thus, in effect, responsible for implementing a large number of communication control procedures, one per student, a most difficult task. For all practical purposes, a teacher, at best, can work only intermittently with each student; whereas, for optimum efficiency, continuous interaction is necessary. The problem is to find a way in which continuous communication and control can replace occasional communication and control, since it is impossible to provide each learner with a private teacher, to achieve educational efficiency with economy.[3]

Consensus re Learning Theory

In the realm of learning theory there is still a good deal of disagreement among psychologists as to exactly how the process called learning is accomplished. Forbes has attempted to establish three points upon which there is some measure of agreement.[4]

---

[3]L. M. Stolurow, Teaching by Machine, Washington: U. S. Government Printing Office, 1962, pp. 4-5.

[4]Jack E. Forbes. "Programmed Instructional Materials - Past, Present and Future." The Mathematics Teacher, Vol. 56, No. 4, April 1963, pp. 224-227.

(1) Learning is not a passive but an active process. The optimum learning situation provides for some degree of interaction between the learner and the material to be learned.

(2) Learning progress is greater when the learner is informed of his progress; that is to say that learning is improved if there is "reinforcement" of correct responses and "blocking" of incorrect responses.

(3) An optimum learning situation is one in which well defined goals are established. These goals should be behaviouristic in nature since generalities such as "understanding", "appreciation", etc., can only be observed from behaviour.

Beyond these three points, Forbes states that there is a decided split.[5] The split is not the result of programming for it pre-dates most of the work in this new field. There are various learning theories which are brought to mind by names such as Thorndike and Gestalt. It may well be that programmed instruction will permit more scientific exploration of all learning theory and thus be used to the lasting benefit of learners everywhere.

II. THE NATURE OF PROGRAMMED INSTRUCTION

Teaching Machines

Much of the literature dealing with programmed instruction deals

---

[5] *Ibid.*, pp. 224-225.

with the "hardware" or the machines used to establish an interaction between the student and the program. It is not proposed here to deal to any degree with the technical aspects of teaching machines since these will, no doubt, change rapidly in years to come.

It should be mentioned, however, from the historical point of view that as early as 1866, Halcyon Skinner developed and patented a spelling machine. About 1873 Jevons developed a logic machine which generated solutions to logical problems represented symbolically. Ordahl and Ordahl built a simple teaching machine to help mentally retarded children acquire certain skills. H. B. English invented a device used in 1918 to help train soldiers to squeeze a rifle trigger.

Beginning about 1915, S. L. Pressey at Ohio State University made a deliberate effort to mechanize both testing and teaching. Pressey's early devices were designed mainly to supplement regular classroom instruction, providing the student with rapid knowledge of results through the immediate scoring of answers. At the present time there are over one hundred different devices available which vary from the simple flash card to the intricate, multi-track, electronically controlled, automatic instructor. A detailed description of these is not within the scope of this study.

Certain critical requirements of any teaching machine are listed by Stolurow.[6] These are:

---

[6]Stolurow, op. cit., p. 6.

(1) Display. This involves the use of appropriate communication channels - visual, auditory, tactual, or a combination to present subject matter information to the learner in accordance with the nature of the material to be taught.

(2) Response. This is a requirement of the learner. It may take the form of pressing a key, composing a written answer, or it may be simply a covert response.

(3) Pacing. This requirement is implemented by a pacing unit or timing device which can alter either or both of two critical time intervals (a) between the time of the question and the presentation of the correct information or answer; and (b) between one question and another. Any particular program may be arranged with fixed interval pacing, variable interval pacing, or it may be self-pacing.

(4) Comparator. This requirement is met by a comparator unit. This unit either automatically analyses the learner's response by comparing it with the correct response stored in the machine or it allows the learner to make this comparison for himself.

(5) Knowledge of Results or Feedback. This is a requirement for communicating to the learner the correctness or incorrectness of his response. The most common type of feedback occurs when the learner is allowed to compare his response with the criterion or correct response; in that case it may be a bi-product of the comparator function. However, the feedback

process may be implemented by the machine - a somewhat desirable feature if the learner is a young child or low in ability. One type of machine, for instance, delivers a token reward when the learner is right and nothing when he is wrong.

(6) Collator Recorder. This is the requirement to measure and record the learning process. Such data as the number of errors, the type of error, the time intervals required for response, etc. are collected and recorded. The collator records each item in such a way that each item is collated with the part of the program to which it pertains. Thus the teacher is able to diagnose immediately the learner's difficulties. Information from the collator is also useful in making improvements in the instructional program. The more complex and sophisticated teaching machines use data collated by the recorder through the selector unit to decide upon the next item of information to present to the learner. When equipped with timing data, the machine may also decide upon the subsequent rate of presentation.

(7) Selector. The selector chooses the next item in the program depending on whether the response to the previous question was right or wrong. Following a wrong response there is either no change in the display or a previous display,

intended to correct the error, appears. If the response is correct, the next display is presented. Here again the more sophisticated machines feature a highly complex selector unit which operates according to the pattern of previous responses.

(8) Library. This provides for the storage of information to be used as needed by the learner. Features of the library are capacity, access time, form and medium of storage.

(9) Programming. This involves the sequencing of items. A sequence can be entirely re-determined as in the linear or non-interpretive program or it can be determined as the learner makes his responses such as in the branching or non-interpretive program. With the linear program there is no variation in the initial sequence in which information and questions are presented. The branching program, on the other hand, provides for alternate routes for students who show different error patterns in their previous responses.

(10) Computor. This is a requirement in the more complex teaching machine. The computor's function is to compose variant programs from a basic program as required by the learner in the course of the teaching session. Thus the modern teaching machine allows for a more complete adaptation of the program to the needs of the learner.

The Two Types of Programming

Much of the literature on programmed instruction does not clearly distinguish between the two main types. These are linear and intrinsic programming. One of the foremost proponents of the latter, N. E. Crowder, points out the basic differences between the two types of programmed instruction.

> The objective of both schools of programming is to produce materials that permit efficient individual study by a student independent of an organized study group and without the continuous intercession of a live instructor. Now, materials suitable for independent study, e.g., text books and reference materials, have been in use for many years. The educator may then well ask the proponents of programmed instruction why they expect their materials to be more effective than the conventional materials. The answers given by the theorists of the two schools of programming are quite different. The linear theorist will describe a particular model of the learning process which he believes is accurate and general enough for practical educational use. He will then show how materials prepared for the linear method follow the requirements of this specific learning model and hence, should, in use, promote efficient learning. In the case of linear programming it is fair to say that the specific learning theory came first; the techniques used derive directly from the theory.
>
> For intrinsic programming, the situation is the reverse. The intrinsic programming theorist will not point to a specific learning model but will rather describe a technique which, in common sense terms, appears to permit inanimate materials to assume some of the educational functions that had previously required a live instructor, or tutor, for each student. Thus, while the linear programmer is exploiting a particular theory, the intrinsic programmer is exploiting a particular technique. The linear programmer is in effect claiming to have discovered something about the learning process which he is putting to practical use with his materials; the intrinsic programmer does not claim to have discovered something about learning but rather to have developed a new technique that allows some rather old ideas

about teaching to be more effectively implemented.[7]

Crowder also describes the differences between linear and intrinsic programming in regard to theory and technique.

> The format of linear materials is by now familiar to most educators. Following a very short presentation of new material, the student is required to emit a response, usually the writing of a word. He then compares his response to the correct response (which he discovers by appropriate manipulation of the materials such as turning to the next page), and if his response matches the correct response, he feels thereby rewarded, and the act is thus "learned". <u>In linear programming the student's response is considered an integral part of the learning process; the response is induced in order that it may be rewarded and learning thus occur</u>. In the strict application of linear theory, the question of how the student is induced to emit the correct response is irrelevant; the important thing is to get the response emitted in order that it may be rewarded and "learned".
>
> Linear programs make no explicit provision for errors by the student, since errors are, by linear theory, simply irrelevant to the learning process.
>
> . . . .
>
> Intrinsic programming makes no assumptions about the nature of the learning process which have not been common educational coin for some time. Furthermore, as suggested above, intrinsic programming is not a theory about how education should be conducted. It is a technique for preparing written materials that will accommodate quite a range of educational purposes. Accordingly, the technique will be described before the theoretical issues.
>
> The technique is based on this simple fact: the student's choice of an answer to a multiple choice question can be used automatically to direct him to new material; the student who chooses one alternative can automatically be directed to

---

[7] N. A. Crowder, "On the Differences Between Linear and Intrinsic Programming." <u>Phi Delta Kappan</u>, Vol. 44, No. 6, March 1963, p. 250.

> different material than that to which a student choosing a different alternative is directed. One use that can be made of the technique is to include in ordinary expository text, questions that are automatically administered scored and appropriate remedial action taken, if indicated.[8]

The program used in this study, viz. English 2600, is of the linear type. Frames are arranged horizontally in a programmed text book. Consequently any conclusions drawn from this experiment may properly be applied to linear but not to intrinsic programming.

III. RELATED STUDIES AND RESEARCH

The I.B.M. Centre Teaching Machine Project

A study of the psychological variables which are important in the design of teaching machines was the topic of a study done by Rath, Anderson and Brainerd at the I.B.M. Research Centre.[9] The project was concerned with the general characteristics of teaching machines as opposed to the development of a particular machine. The purpose of the project centred on three basic problems:

(a) what subject matter was to be taught,

(b) the characteristics of a machine that could be simulated on the I.B.M. high speed digital computer and,

(c) the vehicle for the simulation.

---

[8] *Ibid.*, p. 251.

[9] G. J. Rath, N. S. Anderson and R. C. Brainerd, "The I.B.M. Research Centre Teaching Machine Project," *Automatic Teaching: the State of the Art*. Galantes, E. Editor. New York: John Wiley and Sons, 1959, pp. 117-129.

The subject to be taught was binary arithmetic. This topic was chosen partly because it is a subject of particular interest to the users of high speed computers. Binary arithmetic has the further advantage of containing a small number of new concepts which must be learned. These concepts can be developed upon the concepts of decimal arithmetic, which, it was assumed, had already been established. The program began with a counting routine in which the student first omitted the digit 9, then the 8 and finally arrived at the point where he was counting using just the two digits, 0 and 1. This was followed by the fundamental operations of addition, subtraction, multiplication and division using just the two digits.

The I.B.M. 650 high speed digital computer proved to be an excellent vehicle for the simulation of a teaching machine. It was exceedingly flexible in that changes could be made in the teaching method; frames could be inserted, re-arranged or withdrawn with ease. By simply changing the instructions to the computer, the program could be altered immediately on the basis of student error. The program made allowance also for individual differences in skill level and rate of learning. If the student was making no errors he was given the option of skipping 1, 2 or no problems. After he entered his choice, the program was modified and presented a new problem dependent upon his choice.

In addition, certain psychological principles of efficient learning were built into the program. First, the learner was required

to construct his own response. The computer presented each problem to the student by way of a typewriter located at the Inquiry Station. The student in turn typed his answer which was transmitted to the computer for checking. If the response were correct, the computer presented another frame. If it were incorrect, the computer typed "Wrong", and modified its program. Immediate knowledge of results provided the reinforcement factor. Also the subject matter was presented at a rate in keeping with the student's ability.

Results from the above experiment showed that a computer could, in fact, simulate practically all the features of a teaching machine. Moreover, adjustments to the program could be made quickly and easily in the light of student error.

One disadvantage of this experiment was that only one student was accommodated at a time. This difficulty could easily be overcome by multiplexing the computer so that it would present and score problems of several students placed at different Inquiry Stations.

It was also concluded that binary arithmetic was a subject which lent itself readily to the programming technique.

Some Experimental Results in Schools

Deterline summarized a number of findings of recent experiments in the field of programmed instruction. He states:

> The first really extensive field study designed to test the effectiveness of auto-instruction was conducted by Klaus and Lumsdaine (1960, 1961). A Skinner-type program consisting of some 3000 frames was constructed in programmed textbook form

to cover approximately six weeks of the standard high school physics course. Specifically it covered the topics of static electricity and direct current and the reflection and refraction of light. Classes from fifteen Pittsburg high schools provided a total of approximately 450 subjects. Apart from the program, all students were given classroom lectures, laboratory demonstrations and televised, Harvey E. White television films and a text book. The students also performed laboratory demonstrations themselves under supervision. The standard teaching procedure, it is clear, subjected the students to a rather broad barrage of physics presentations. The experimental design was rather complex; some classes used all sections of the program, some classes used only one or two of the sections and some did not use any part of the program. For each section of the physics course, all students used a standard text book and attended classroom lectures, laboratory sessions and televised lectures. In addition, students in some of the high schools used the program for additional coverage of the same topics. Unless the standard teaching procedures were producing the maximum potential learning by all students, any increase on the part of the students using the program could simply be attributed to the added time spent on the program. To add a means of measuring any possible effects of sheer additional study time, some classes were given additional study workbooks paralleling the coverage of the program. Under these conditions, the performance of the students using the workbooks could be compared with that of the students whose additional time was spent working on the program.

The results indicated that the classes using the programs did better on an achievement test than students who had used neither program nor workbook. The workbook classes were superior to those having neither workbook nor program but were inferior in performance to the classes which had used the program.[10]

In another study done by the same research team, high school classes were used in a slightly different way; some were instructed by program only, while others had the program plus teacher instruction.

---

[10] W. A. Deterline, An Introduction to Programmed Instruction, Englewood Cliffs, N. J.: Prentice Hall, 1962, pp. 61-62.

There was no significant difference in performance gain level. Thus, from this study it would appear that when a program was used in a certain subject area, the teacher, instead of covering the same topic, could devote his time to more important instructional functions.

College Level Research

Some research has been conducted at the college level. One such experiment was carried out by Hough and Revsin at Temple University.

Among the research questions asked were the following:

1. Does programmed instruction presented by selected response-mode teaching machine produce more learning than the same program presented by means of a programmed text-book?

2. Does immediate knowledge of the correctness of a response, i.e., reinforcement, produce more learning than responding without knowledge of results?

3. When programmed learning is used as a means of instruction at the college level, what factors differentiate high achievers from low achievers?

Previous studies which have compared the effectiveness of teaching machines and programmed texts have failed to find any significant differences.[11]

In order to answer the above questions the following procedure was followed at Temple:

---

[11] J. B. Hough and B. Revsin, "Programmed Instruction at the College Level: A Study of Several Factors Influencing Learning," Phi Delta Kappan, Vol. 44, No. 6, March 1963, p. 286.

This study involved ninety students in the Department of Secondary Education at Temple University. The programmed instruction was a regular part of the course titled, "The Contemporary Secondary School," a junior level course required of all students in the department. Classes in the fall and spring semesters of the academic year 1961-62 were used and programmed instruction involved three weeks out of each semester. The program taught the content on the historic foundations of the secondary school, a regular part of the content of this course. During the three weeks when the experiment was being conducted each semester, students reported to a teaching machine laboratory for two sessions of programmed instruction each week to be tested and to discuss the content taught in the program.

The programmed materials were prepared in three ways: (1) for use in an electro-mechanical selected-response teaching machine, (2) as a horizontal programmed text with reinforcement frames following each response frame, and (3) as a horizontal programmed text with the reinforcement frames left blank thus providing no knowledge of results. The content was identical frame by frame in each of the three program types. No supplementary or parallel text material was provided the students during the course of the experiment.[12]

The results of this study were summarized.

No difference in achievement could be found between students using electro-mechanical teaching machines, programmed text-books or programmed text-books with re-inforcement frames removed. A comparison of high and low achieving students indicated that these two groups of students did not differ significantly in regard to verbal ability, attitude toward programmed instruction, attitude toward the content being studied, or on personality traits used for comparison. A hypothesis regarding moti-vation as a function of long range goal identification was proposed as a possible explanation for the significantly different achievement of the two groups.[13]

---

[12] Ibid., p. 287.

[13] Ibid., p. 291.

A Related Project

In the field of English, Reed and Hayman[14] have provided some experimental evidence based upon the use of the programmed textbook, English 2600. Their findings showed that there was a substantial amount of learning by students who had worked through the program as indicated by the results of a standardized language test. They found also, that at the tenth grade level the program proved to be most effective with students of high ability. Those with low ability seemed to learn more effectively through standard classroom instruction.

It would appear, then, that much more research is needed in the field of programmed instruction before the educator may decide whether this device merits his serious consideration. The experiment described in this thesis is intended to shed some light on this basic question.

---

[14]Jerry E. Reed and John L. Hayman, "An Experiment Involving Use of English 2600, an Automated Instruction Text." The Journal of Educational Research, Vol. 28, No. 9, June-July 1962, pp. 476-484.

CHAPTER III

THEORETICAL FRAMEWORK, HYPOTHESES AND EXPERIMENTAL DESIGN

Since 1958, when B. F. Skinner presented his now famous paper on automated instruction,[1] the teaching machine-programmed instruction movement has grown in band-wagon fashion. Much of the theory behind the movement sounds very convincing indeed. It might be desirable at this point, to summarize this supporting theory and also indicate some of the criticisms which have been levelled at programmed learning.

I. THEORETICAL FRAMEWORK

Supporting Theory

Reinforcement would appear to be the central pillar upon which the theory of programmed instruction is hung. A child makes a response to a stimulus. If this response is the one which the programmer wants, it is rewarded and thus reinforced. Reinforcement is of prime significance in the development of the linear or Skinnerian program.

Immediate knowledge of results is believed to be a desirable factor in learning and is a feature of any program.

---

[1] B. F. Skinner, "Programming Verbal Knowledge for Automated Instruction in Schools and Colleges," American Psychologist, 1958.

<u>The accretion of learning through small steps</u> is a principle applied in the construction of most programs. This would appear necessary to enable the student to work his way through the program without guidance from a teacher.

<u>Individual differences of students</u> are taken into consideration in two ways. First in regard to timing, students go at their own speed. The brighter person will complete a body of work in less time than his classmates and may be allowed to proceed to more challenging studies. The slower learner, on the other hand, will require more time but will eventually cover the same basic curriculum as the more gifted. Second, the program itself is self-adapting to individual needs in regard to difficulty of content, this being particularly true of the branching program. Here, the route which the learner takes is entirely dependent upon his responses. Presumably, if he needs remedial work - more drill on the basic fundamentals - this he will have; if his basic knowledge of a certain topic is already sound, the program will carry him straight through to more advanced material.

<u>The child learns by doing</u>. This principle too, has been recognized in that the student is in continuous interaction with the program. Student responses may be overt, e.g., pressing a button, writing a word, phrase or sentence; or they may be covert in which case the student merely "thinks" the answer without recording it in any way. Experiments comparing the advantages of these two methods are inconclusive.

Programmed instruction is valuable in research. Many proponents of this new technique feel that the research feature may eventually be by far the most important aspect of programming. It is now possible to control the one confounding variable which has plagued much research in the field of teaching methodology. Very often it has been found that the personal qualities of the teacher have over-ridden other conditions of instruction to the point where comparisons of method were meaningless. With the teacher variable removed, it may be possible to build a more scientifically sound structure of teaching theory as an adjunct to learning theory.

Criticism

There are many educators who do not subscribe to this current trend in education. One of the more fluent critics, J. F. Wohlwill, is not impressed:

> I offer that the theoretical foundation on which this work allegedly rests is tenuous and unconvincing; that the adequacy of present day programming is questionable in the light of our knowledge - and lack thereof - of relevant aspects of the learning process; and perhaps most important, the teaching machine movement is built on and fosters a very narrowly conceived debatable view of the educational process and of the philosophy of education.
>
> Skinner and his associates have repeatedly claimed that the rationale of the teaching machine is backed up by well established principles of learning which have emerged from extensive research in the psychological laboratory. However, except for attention given to immediate reinforcement of responses, the particular relevance of the vocabulary work to the learning of a program by teaching machine is largely left to the imagination. This is not surprising given the considerable gap to be bridged between the acquisition of a bar-pressing response by a pigeon

in the Skinner box and the writing of a verbal response by a student in the frame of a machine program.

. . . .

Another aspect of learning conspicuously neglected by machine instruction is verbal expression. While educators at all levels recognize improved expression as a major need and are emphasizing the importance of essays and oral reports, a strategy of teaching which rarely allows the student to emit a sequence of even two words seems hardly calculated to help in meeting this need. Seen in this context, the controversy between proponents of Skinner's approach in which the learner composes his answer, and the advocates of multiple-choice responses fades into insignificance.[2]

Here is the opinion of one severe critic of programmed instruction. His comment regarding the insignificance of the type of response to be used does point up the necessity for a basic type of research. What most educators wish to know is whether students do learn through programmed instruction and how well they learn. A further question arises as to what type of learning is carried on most effectively through this method and also, what type is least effectively handled. As Mr. Wohlwill so aptly pointed out, essay-writing would not appear to lend itself readily to the programming procedure. However, such conclusions should not be drawn without experimental evidence

---

[2] J. F. Wohlwill, "The Teaching Machine; Psychology's New Hobby Horse," The Educational Digest, Vol. 28, No. 6, Feb. 1963, p. 5.

II. SPECIFIC HYPOTHESES

In this experiment the specific hypotheses were:

(a) Students who completed a program of instruction in the mechanics of English, would achieve a greater mean gain score on a standardized language test than those who did not.

(b) The difference in mean gain score referred to in (a) would be statistically significant.

(c) Mean gain scores on each of the sub-tests, viz., capitalization, punctuation, word usage and spelling, would also be significantly different for the two groups.

(d) A significant positive correlation would exist between mean gain score and I.Q. for the experimental group.

(e) Mean grade placement of the experimental group (California Achievement Test Table) would be increased appreciably.

III. EXPERIMENTAL DESIGN

The Test Sample

It was decided to use as subjects for this experiment the ninety-two students in Grade VIII at the Fort Saskatchewan Junior High School. From this number, forty-six were selected to serve as the experimental group. This was done by arranging the entire group alphabetically and then using a table of random numbers to select the experimental subjects. The remaining forty-six became the control group. Since one member of the control group missed school during most of the experimental period

he was not included in the study, thus reducing the control group to forty-five.

The I.Q. in the sample ranged from eighty-four to one hundred forty-five. The mean I.Q. for the experimental group was one hundred twelve and for the experimental group one hundred fifteen. The age varied from twelve years four months to sixteen years four months. The mean age of the experimental group was fourteen years no months. The mean age of the control group was fourteen years one month.

The experimental and control groups were not matched but rather selected on a random basis. A comparison of the two groups showed that on the pre-test their mean scores were quite similar although the experimental group showed a somewhat greater standard deviation.

Table I shows the scores of all experimental subjects on the California Achievement Test in Language (pre-test) and the squared deviation for each individual's score. From these data the mean score, X, and the total squared deviation has been obtained.

Table II shows the scores of all control subjects on the California Achievement Test in Language (pre-test) and the squared deviation for each individual's score. From these data the mean score, X, and the total squared deviation has been obtained.

Table III compares, in particular, the mean scores and the standard deviations for the two groups. The mean scores were almost identical - 104.30 and 103.84 while the standard deviations differed

TABLE I

TOTAL SCORE AND SQUARED DEVIATIONS FOR EXPERIMENTAL SUBJECTS ON CALIFORNIA ACHIEVEMENT TEST IN LANGUAGE, FORM W (PRE-TEST)

Student Number	Total Score Pre-Test	$(X-\bar{X})^2$
1	98	36
2	109	25
3	116	144
4	119	225
5	78	676
6	99	25
7	119	196
8	104	0
9	98	36
10	88	256
11	114	100
12	87	289
13	102	4
14	105	1
15	107	9
16	102	4
17	122	324
18	98	36
19	112	64
20	118	196
21	95	81
22	66	1,444
23	95	81
24	95	81

TABLE I (continued)

Student Number	Total Score Pre-Test	$(X-\bar{X})^2$
25	121	289
26	118	196
27	121	289
28	117	169
29	116	112
30	94	100
31	93	121
32	95	81
33	116	144
34	98	36
35	109	25
36	114	100
37	118	196
38	89	225
39	114	100
40	105	1
41	111	49
42	113	81
43	103	1
44	101	9
45	113	81
46	73	961
	$\Sigma X = 4{,}798$	$X = 104.30$ $\Sigma(X-\bar{X})^2 = 7{,}699$

TABLE II

TOTAL SCORE AND SQUARED DEVIATIONS FOR CONTROL SUBJECTS ON CALIFORNIA ACHIEVEMENT TEST IN LANGUAGE (PRE-TEST)

Student Number	Total Score Pre-Test	$(X-\bar{X})^2$
1	101	9
2	118	196
3	109	25
4	104	0
5	100	16
6	88	256
7	110	36
8	98	36
9	89	225
10	117	169
11	123	361
12	117	169
13	113	81
14	114	100
15	100	16
16	112	64
17	98	36
18	107	9
19	110	36
20	106	4
21	93	121
22	114	100
23	105	1
24	119	225

TABLE II (continued)

Student Number	Total Score Pre-Test	$(X-\bar{X})^2$
25	104	0
26	111	49
27	115	121
28	89	225
29	106	4
30	90	196
31	96	64
32	117	169
33	94	64
34	103	1
35	119	225
36	98	36
37	95	81
38	90	196
39	117	169
40	89	225
41	118	196
42	89	225
43	102	4
44	81	529
45	85	361
		5,431

$\sum X = 4{,}673$, $\bar{X} = 103.84$ $\sum(X-\bar{X})^2 = 5{,}431$

appreciably - 12.94 and 10.98.

It may be concluded that the two groups of students were very similar in respect to language ability at the outset of this experiment.

TABLE III

COMPARISON OF SCORES OF EXPERIMENTAL AND CONTROL GROUPS ON THE PRE-TEST CALIFORNIA ACHIEVEMENT TEST IN LANGUAGE JUNIOR HIGH LEVEL, 1957 EDITION

	Experimental Group	Control Group
N	46	45
ΣX	4,798	4,673
$\bar{X}$	104.30	103.84
$\Sigma(X-\bar{X})^2$	7,699	5,431
S	12.94	10.98

The English 2600 Program

The instructional instrument, English 2600 (Revised Edition) by Joseph Blumenthal, is a programmed textbook.[3] The pages are divided into panels, six to a page. Instead of reading the page from top to bottom, as in an ordinary textbook, the student reads just the top panel. He then turns the page to the top panel of page three,

[3] J. C. Blumenthal, English 2600, New York: Harcourt Brace, 1960.

then to the top panel of page five and so on to the end of the book. He then returns to the beginning and proceeds with the second panel on every odd-numbered page. He proceeds in this manner until he completes the six panels on the odd-numbered pages, then does the same with the even-numbered pages. Provided a student does not cheat by turning forward to the answer before he has given his response, the written record will show exactly how many errors he actually made.

Reed and Hayman have reported on cheating:

> Despite extreme efforts to introduce the method of study to the pupils adequately, some pupils were found to cheat, particularly among the low achiever groups ... Two of five teachers felt that cheating was no problem; they were unaware of any cheating on the part of their pupils.[4]

The programmed textbook, English 2600 covers much of the content of English grammar, punctuation, capitalization and spelling in 2632 items to which the learner must respond. It offers, theoretically, to the teacher of English a type of self-correcting assignment which would relieve that teacher of the necessity of teaching, offering practice in and testing many mechanical aspects of the English language. The material is arranged according to the principles of programming so that the child should be able to work through it without benefit of explanations from the teacher. Content is divided

---

[4]Read and Hayman, op. cit., p. 478.

into eleven sections. Accompanying the programmed text is a test booklet containing a pre-test, a post-test as well as tests on each of the eleven sections.

<u>The Testing Instrument</u>

This consisted of two forms of the California Achievement Test in Language, Junior High Level 1957 edition, forms W and X. The publisher of this test has stated that the reliability coefficient is .93. Also included is what is called a standard error of measurement in grade placement. For the language test the chances are 2 to 1 that the examinee's grade placement on the test will not vary from his true grade placement by more than five months and nine to one that it will not vary by more than ten months.

In regard to validity, the California Achievement Tests, Junior High Level is described under two headings: (a) Content Validity and (b) Construct Validity.

To establish the former, a rationale for the test is given as well as curriculum and item studies. The items were selected to measure the most universal subject matter in a curriculum. Although curricula differ widely from one school system to another, there are certain basic skills and tests of learning which are basic to all. Thus the test scores do show the extent of student mastery of the fundamental skills in terms of grade placements and percentiles based upon a carefully sampled and broad population. Items are designed specifically to evaluate the ability of the examinee to make

intelligent use of the skills and facts in his possession to solve new problems, to make inferences and to draw conclusions.

Five revisions have been made in this instrument in order to eliminate any items which were not considered valid. While many of the items of the original battery have survived the numerous revisions, all those in the present form have proven to be highly acceptable by modern standards. The present edition has been referred to a panel of curriculum experts including research specialists, professors, teachers and department of education officials. On a rating scale from A to E, the items on the mechanics of English test were rated as follows: A - 66 per cent, B - 33 per cent, C - 1 per cent.

The discrimination of the four forms of the tests are expressed as phi coefficients. These are indices of the power of each item to discriminate between those who score high and those who score low in terms of the total score for each test. Only 17 per cent of the items on the four forms of the test show a phi coefficient of less than .2.

Regarding construct validity, the scores of the California Achievement Test have been compared to scores on other standardized tests, including the Metropolitan English Tests I, II and III and the Stanford Language Test 4. The correlation coefficient in the first case was .81 and in the second .62.

On the basis of the above, it was reasonable to assume that students' scores in language using this test were sufficiently accurate to justify statistical analysis.

Experimental Procedure

On April 11, 1963, the California Achievement Test in Language, Junior High Level, 1957 Edition Form W was administered to all grade eight students in the Fort Saskatchewan Junior High School. On April 25 the experimental group of forty-six students commenced working on the programmed textbook, English 2600. Thirty school days later, June 7, 1963, when the program had been completed, the alternate Form X of the California Achievement Test was administered to experimental and the control groups.

During the six-week period the experimental group spent one 35-minute period per day working on the program. In order to keep the members of the group together it was necessary to allow the slower members to devote two periods per day to the program. Similarly, those students who worked most quickly were assigned to other studies until their classmates caught up. These adjustments were made during the fourth and fifth weeks of the program so that all students finished at approximately the same time. Consequently, all students wrote the post-test simultaneously and the effects of forgetting were minimized. Total time spent on the program varied from twelve to twenty-one hours.

During the six-week period, the control-group members were engaged in homework assignments during the time that those in the experimental group were working through the program. No formal instruction was given by the teachers to either group but both groups were supervised. The teachers supervising the experimental group gave no

assistance or explanation.

Responses by the students were made overtly. They wrote these on a sheet of foolscap, then turned the page and checked them. Teachers did not note any cases of cheating of the type reported by Reed and Hayman.[5] Each student placed his answer sheets in his file folder as they were completed. Examination of these sheets revealed no evidence of cheating.

The two groups wrote the pre-test and the post-test under identical conditions. In fact, the members of the two groups were indiscriminately mixed while the tests were being written. Thus, the essential difference between the groups was the fact that during the six-week interval between tests, one had worked through a program in English language while the other had not.

---

[5] Ibid., p. 478.

CHAPTER IV

COLLECTION AND TREATMENT OF DATA

Time Factors

The publisher of the programmed textbook, English 2600[1] states that the time required to complete the program varies from nine to twenty hours. This statement proved to be reasonably accurate. Students in grade eight in Fort Saskatchewan Junior High School varied from twelve to twenty-one hours in time required. The majority of students completed the program in approximately fourteen hours. This included the time devoted to completing all the tests that accompany the textbook.

The Null Hypothesis

A treatment was applied to the experimental group. The treatment was absent from the control group. Hence, any significant difference between the two groups was ascribed to the treatment and to no other cause. $\bar{X}_1$ and $\bar{X}_2$ represented the mean gain scores for the experimental and the control groups respectively. Both means were subject to sampling error. The means $\bar{X}_1$ and $\bar{X}_2$ were estimates of the population means U_1 and U_2. The null hypothesis was written, $Ho : U_1 - U_2 = 0$.

---

[1] J. C. Blumenthal, English 2600. New York: Harcourt, Brace and World, Inc., 1960.

Very simply stated, this hypothesis asserted that there was no difference between the population means.

The data were then examined. The difference between the mean gain score for the experimental group and the mean gain score for the control group was tested for significance.

Tests of Significance

The t-test for significance was the one used; it is based upon the following question: What is the probability of obtaining a difference equal to or greater than the one observed in drawing samples at random from populations where the null hypothesis is assumed to be true? In the cases of the two mean gain scores, what is the probability of obtaining a difference equal to or greater than $\bar{X}_1 - \bar{X}_2$ in drawing random samples from the population where $U_1 - U_2 = 0$? If this probability is small, .05 or less, the null hypothesis may be rejected. This means that the observed difference cannot be explained by sampling error and presumably may be attributed to the treatment applied.

Following are the types of data required to perform the above-mentioned test of significance. The test used was the one-tailed t-test comparing two means for independent samples. On the following pages this test of significance has been applied to the following sets of data:

(a) Student scores on capitalization test

(b) Student scores on punctuation test

(c) Student scores on word usage test

(d) Student scores on spelling test

(e) Students' total scores

(f) Students' total scores (comparing students above the class median in I.Q.)

(g) Students' total scores (comparing students below the class median in I.Q.)

Further analyses of results were completed using the experimental group only. A comparison between I.Q. and mean gain score was made by calculating the Pearson product-moment correlation coefficient. As an additional indicator, Spearman's rank correlation coefficient was derived.

In addition to the above, the mean gain scores for the two groups was referred to the California Grade Placement table and increases compared.

__Data for t-tests Applied to Gain Scores in Capitalization, Punctuation, Word Usage, Spelling and Total Test__

The essential data for determining whether significant gains in capitalization score were achieved by members of the experimental group were taken from Tables IV and V. On the page following Table V, these two mean gain scores are compared and a t-test of significance applied. In this and succeeding tables, X stands for an individual student's gain score while $\bar{X}$ represents the average or mean gain score for the entire group.

Similarly, the essential data for determining the significance of the gains in punctuation score were taken from Tables VI and VII. On the page following Table VII the t-test is applied; data for the word usage t-test following Table IX were obtained from Tables VIII

TABLE IV

PROGRAMMED INSTRUCTION - EXPERIMENTAL GROUP
CAPITALIZATION TEST SCORES

Student No.	Possible	Pre Test 30	Post Test 30	Net Change	$(X-\bar{X})^2$
1		24	29	5	12
2		25	29	4	6
3		30	29	-1	6
4		30	30	0	2
5		23	27	4	6
6		26	26	0	2
7		29	29	0	2
8		26	27	1	0
9		24	23	-1	6
10		20	24	4	6
11		27	26	-1	6
12		24	23	-1	6
13		26	28	2	0
14		24	24	0	2
15		28	29	1	0
16		20	23	3	2
17		27	29	2	0
18		26	21	-5	30
19		27	28	1	0
20		27	30	3	2
21		24	24	0	2
22		21	21	0	2
23		25	30	5	12
24		22	25	3	2
25		30	30	0	2
26		29	30	1	0

TABLE IV (continued)

Student No.	Possible	Pre Test 30	Post Test 30	Net Change	$(X-\bar{X})^2$
27		29	30	1	0
28		30	28	-2	12
29		28	29	1	0
30		22	28	6	20
31		25	26	1	0
32		22	25	3	2
33		29	30	1	0
34		21	22	1	0
35		28	28	0	2
36		30	28	-2	12
37		30	29	-1	6
38		24	22	-2	12
39		27	29	2	0
40		25	29	4	6
41		25	29	4	6
42		29	30	1	0
43		24	29	5	12
44		24	26	2	0
45		26	28	2	0
46		10	24	14	56
			Total	71	362
			Mean Gain $(\bar{X})$ = 1.54		

TABLE V

PROGRAMMED INSTRUCTION - CONTROL GROUP
CAPITALIZATION TEST SCORES

Student No.	Possible	Pre Test 30	Post Test 30	Net Change	$(X-\bar{X})^2$
1		25	24	-1	1
2		29	29	0	0
3		30	28	-2	4
4		24	27	3	9
5		21	24	3	9
6		27	29	2	4
7		29	30	1	1
8		27	28	1	1
9		14	15	1	1
10		27	28	1	1
11		30	28	-2	4
12		29	29	0	0
13		28	28	0	0
14		27	25	-2	4
15		24	27	3	9
16		26	29	3	9
17		28	24	-4	16
18		26	27	1	1
19		25	24	-1	1
20		29	29	0	0
21		25	23	-2	4
22		27	27	0	0
23		28	28	0	0
24		29	30	1	1
25		28	26	-2	4
26		25	25	0	0

TABLE V (continued)

Student No.	Possible	Pre Test 30	Post Test 30	Net Change	$(X-\bar{X})^2$
27		30	29	-1	1
28		23	20	-3	9
29		26	23	-3	9
30		27	26	-1	1
31		28	26	-2	4
32		25	26	1	1
33		24	24	0	0
34		28	27	-1	1
35		29	30	1	1
36		22	22	0	0
37		27	30	3	9
38		25	26	1	1
39		29	29	0	0
40		25	23	-2	4
41		30	29	-1	1
42		22	23	1	1
43		25	29	4	16
44		22	22	0	0
45		21	23	2	4
		Total		3	147
		Mean Gain $\bar{X}$ = .07			

and IX while data for the spelling sub-test were taken from Tables X and XI. Tables XII and XIII provided data for determining the significance of the difference in gain score, entire test, between experimental and control groups.

Data Treatment - Capitalization

	Experimental Group	Control Group
N	46	45
ΣX	71	6
$\bar{X}$	1.54	.07
$\Sigma(X-\bar{X})^2$	362	147

The unbiased estimate of variance was:

$$S^2 = \frac{\Sigma(X-\bar{X}_1)^2 + \Sigma(X-\bar{X}_2)^2}{N_1 + N_2 - 2}$$

$$S^2 = \frac{362 + 147}{46 + 45 - 2} = 5.7$$

The "t" ratio was

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S^2}{N_1} + \frac{S^2}{N_2}}}$$

$$= \frac{1.54 - .07}{\sqrt{\frac{5.7}{46} + \frac{5.7}{45}}} = \frac{1.47}{.50}$$

$$= 2.94$$

The number of degrees of freedom was 46 + 45 = 2 = 89. For d.f. 89 a "t" equal to 1.66 was required for significance at the .05 level using a one-tailed test.

Thus it was concluded that the null hypothesis should be rejected i.e., $U_1 \neq U_2$. The difference between the mean gain scores was significant.

TABLE VI

PROGRAMMED INSTRUCTION - EXPERIMENTAL GROUP
PUNCTUATION TEST SCORES

Student No.	Possible	Pre Test 29	Post Test 29	Net Change	$(X-\bar{X})^2$
1		20	25	5	9
2		21	26	5	9
3		24	26	2	0
4		23	26	3	1
5		7	23	16	196
6		22	24	2	0
7		27	28	1	1
8		24	24	0	4
9		22	25	3	1
10		15	25	10	64
11		26	25	-1	9
12		15	19	4	4
13		19	19	0	4
14		22	21	-1	9
15		23	25	2	0
16		26	25	-1	9
17		29	28	-1	9
18		23	8	115	289
19		22	24	2	0
20		27	29	2	0
21		19	22	3	1
22		12	19	7	25
23		22	23	1	1
24		24	17	-7	81
25		26	27	1	1
26		25	27	2	0

TABLE VI (continued)

Student No.	Possible	Pre Test 29	Post Test 29	Net Change	$(X-\bar{X})^2$
27		27	26	-1	9
28		28	28	0	4
29		20	23	3	1
30		17	21	4	4
31		17	22	5	9
32		21	20	-1	9
33		23	28	5	9
34		19	22	3	1
35		22	28	6	16
36		25	26	1	1
37		23	28	5	9
38		20	20	0	4
39		22	25	3	1
40		20	27	7	25
41		24	22	-2	16
42		27	28	1	1
43		24	26	2	0
44		18	24	6	16
45		26	24	-2	16
46		13	18	5	9
			Total	95	887
			Mean Gain $\bar{X}$ =	2.07	

TABLE VII

PROGRAMMED INSTRUCTION - CONTROL GROUP
PUNCTUATION TEST SCORES

Student No.	Possible	Pre Test 29	Post Test 29	Net Change	$(X-\bar{X})^2$
1		18	20	2	0
2		26	24	-2	12
3		17	26	9	56
4		20	25	5	12
5		20	20	0	2
6		13	20	7	30
7		25	23	-2	12
8		23	24	1	0
9		20	18	-2	12
10		26	28	2	0
11		24	27	3	2
12		23	24	1	0
13		21	29	8	42
14		26	26	0	2
15		16	22	6	20
16		26	28	2	0
17		24	21	-3	20
18		22	23	1	0
19		23	13	-10	130
20		17	27	10	72
21		22	17	-5	42
22		24	24	0	2
23		20	23	3	2
24		26	26	0	2
25		22	22	0	2
26		23	25	2	0

TABLE VII (continued)

Student No.	Possible	Pre Test 29	Post Test 29	Net Change	$(X-\bar{X})^2$
27		25	28	3	2
28		9	17	8	42
29		24	21	-3	20
30		20	24	4	6
31		20	19	-1	56
32		24	26	2	0
33		20	21	1	0
34		25	26	1	0
35		26	27	1	0
36		20	19	-1	6
37		19	23	4	6
38		18	18	0	2
39		24	22	-2	12
40		19	21	2	0
41		23	20	-3	20
42		19	28	9	56
43		17	21	4	6
44		22	22	0	2
45		17	18	1	0
		Total		68	660
		Mean Gain $\bar{X}$ = 1.51			

Data Treatment - Punctuation

	Experimental Group	Control Group
N	46	45
ΣX	95	76
$\bar{X}$	2.07	1.51
$\Sigma(X-\bar{X})^2$	887	710

The unbiased estimate of the variance was:

$$s^2 = \frac{\Sigma(X-\bar{X}_1)^2 + \Sigma(X-\bar{X}_2)^2}{N_1 + N_2 - 2}$$

$$= \frac{887 + 710}{89} = 18.0$$

The ratio "t" was
$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s^2}{N_1} + \frac{s^2}{N_2}}}$$

$$t = \frac{2.07 - 1.51}{\sqrt{\frac{18}{46} + \frac{18}{45}}} = \frac{.56}{.89} = .63$$

The number of degrees of freedom was 89. For 89 d.f. a "t" equal to 1.66 was required for significance at the .05 level using a one-tailed test.

The null hypothesis was upheld. There was not a significant difference between the mean gain scores for the two groups.

TABLE VIII

PROGRAMMED INSTRUCTION - EXPERIMENTAL GROUP
WORD USAGE TEST SCORES

Student No.	Possible	Pre Test 40	Post Test 40	Net Change	$(X-\bar{X})^2$
1		32	35	3	6
2		37	37	0	0
3		34	37	3	6
4		38	40	2	2
5		33	34	1	0
6		36	36	0	0
7		39	38	-1	2
8		31	30	-1	2
9		35	33	-2	6
10		35	29	-6	42
11		34	38	4	12
12		27	30	3	6
13		35	34	-1	2
14		35	32	-3	12
15		32	34	2	2
16		36	32	-4	20
17		40	36	-4	20
18		36	35	-1	2
19		36	37	1	0
20		36	39	3	6
21		31	30	-1	2
22		22	25	3	6
23		34	35	1	0
24		33	37	4	12
25		37	39	2	2
26		37	39	2	2

TABLE VIII (continued)

Student No.	Possible	Pre Test 40	Post Test 40	Net Change	$(X-\bar{X})^2$
27		37	38	1	0
28		36	34	-2	6
29		40	40	0	0
30		30	32	2	2
31		37	36	-1	2
32		34	31	-3	12
33		38	40	2	2
34		32	32	0	0
35		35	33	-2	6
36		35	37	2	2
37		37	34	-3	12
38		28	31	3	6
39		36	38	2	2
40		34	37	3	6
41		36	33	-3	12
42		36	37	1	0
43		33	37	4	12
44		38	35	-3	12
45		37	38	1	0
46		31	34	3	6
			Total	17	272
			Mean Gain $\bar{X}$ = .37		

TABLE IX

PROGRAMMED INSTRUCTION - CONTROL GROUP
WORD USAGE TEST SCORES

Student No.	Possible	Pre Test 40	Post Test 40	Net Change	$(X-\bar{X})^2$
1		35	32	-3	4
2		38	38	0	1
3		36	37	1	4
4		38	35	-3	4
5		35	34	-1	0
6		29	23	-6	25
7		34	36	2	9
8		30	32	2	9
9		34	35	1	4
10		35	39	4	25
11		40	38	-2	1
12		37	36	-1	0
13		38	37	-1	0
14		34	25	-9	64
15		36	37	1	4
16		39	40	1	4
17		33	34	1	4
18		38	39	1	4
19		36	34	-2	1
20		37	38	1	4
21		26	32	6	49
22		37	31	-6	25
23		34	31	-3	4
24		38	35	-3	4
25		32	26	-6	5
26		38	36	-2	1

TABLE IX (continued)

Student No.	Possible	Pre Test 40	Post Test 40	Net Change	$(X-\bar{X})^2$
27		36	37	1	4
28		31	25	-6	25
29		33	32	-1	0
30		29	29	0	1
31		29	22	-7	36
32		40	38	-2	1
33		33	31	-2	1
34		33	33	0	1
35		38	36	-2	1
36		32	31	-1	0
37		34	35	1	4
38		30	27	-3	4
39		36	38	2	9
40		28	31	3	16
41		37	38	1	4
42		30	35	5	36
43		34	33	-1	0
44		23	31	8	81
45		31	27	-4	9
			Total	-35	492

Mean Gain $\bar{X}$ = .78

Data Treatment - Word Usage

	Experimental Group	Control Group
N	46	45
$\sum X$	17	-35
$\bar{X}$	0.37	- 0.78
$\sum(X-\bar{X})^2$	272	492

The unbiased estimate of the variance was

$$s^2 = \frac{\sum(X-\bar{X}_1)^2 + \sum(X-\bar{X}_2)^2}{N_1 + N_2 - 2} = \frac{272 + 492}{89}$$

$$= 8.6$$

The ratio "t" was:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s^2}{N_1} + \frac{s^2}{N_2}}}$$

$$t = \frac{.37 - -0.78}{\sqrt{\frac{8.6}{46} + \frac{8.6}{45}}} = \frac{1.15}{.61} = 1.9$$

There were 89 degrees of freedom. For a d.f. of 89 a "t" equal to 1.66 was required for significance at the .05 level using a one-tailed test.

It was justifiable to reject the null hypothesis. There was a significant difference between the gain scores for the two groups.

TABLE X

PROGRAMMED INSTRUCTION - EXPERIMENTAL GROUP
SPELLING TEST SCORES

Student No.	Possible	Pre Test 30	Post Test 30	Net Change	$(X-\bar{X})^2$
1		22	30	8	49
2		26	25	-1	4
3		28	28	0	1
4		28	30	2	1
5		15	21	6	25
6		15	20	5	16
7		24	27	3	4
8		23	21	-2	9
9		17	21	4	9
10		18	21	3	4
11		27	29	2	1
12		21	21	0	1
13		22	17	-5	36
14		24	27	3	4
15		24	25	1	0
16		20	17	-3	16
17		26	26	0	1
18		13	11	-2	9
19		27	28	1	0
20		28	29	1	0
21		21	26	5	16
22		11	11	0	1
23		14	24	10	81
24		16	19	3	4
25		28	29	1	0
26		27	27	0	1

TABLE X (continued)

Student No.	Possible	Pre Test 30	Post Test 30	Net Change	$(X-\bar{X})^2$
27		28	28	0	1
28		23	23	0	1
29		28	28	0	1
30		25	24	-1	4
31		14	21	7	36
32		18	15	-3	16
33		26	27	1	0
34		26	19	-7	64
35		24	21	-3	16
36		24	25	1	0
37		28	27	-1	4
38		17	20	3	4
39		29	29	0	1
40		26	30	4	9
41		26	28	2	1
42		21	27	6	25
43		22	24	2	1
44		21	23	2	1
45		24	24	0	1
46		19	16	-3	16
			Total	55	495

Mean Gain $\bar{X}$ = 1.19

TABLE XI

PROGRAMMED INSTRUCTION - CONTROL GROUP
SPELLING TEST SCORES

Student No.	Possible	Pre Test 30	Post Test 30	Net Change	$(X-\bar{X})^2$
1		23	25	2	1
2		25	29	4	9
3		26	28	2	1
4		22	20	-2	9
5		24	21	-3	16
6		19	19	0	1
7		22	24	2	1
8		18	23	5	16
9		21	19	-2	9
10		29	30	1	0
11		29	28	-1	4
12		28	26	-2	9
13		26	23	-3	16
14		27	27	0	1
15		24	23	-1	4
16		21	20	-1	4
17		13	13	0	1
18		21	24	3	4
19		26	28	2	1
20		23	27	4	9
21		20	19	-1	4
22		26	24	-2	9
23		23	28	5	16
24		26	28	2	1
25		22	27	5	16
26		25	26	1	0

TABLE XI (continued)

Student No.	Possible	Pre Test 30	Post Test 30	Net Change	$(X-\bar{X})^2$
27		24	29	5	16
28		26	25	-1	4
29		23	23	0	1
30		14	18	4	9
31		19	16	-3	16
32		28	29	1	0
33		17	17	0	1
34		17	20	3	4
35		26	27	1	0
36		24	21	-3	16
37		15	16	1	0
38		17	21	4	9
39		28	30	2	1
40		17	19	2	1
41		28	28	0	1
42		18	22	4	9
43		26	24	-2	9
44		14	18	4	9
45		16	17	1	0
		Total		43	268

Mean Gain $\bar{X}$ = .96

Data Treatment - Spelling

	Experimental Group	Control Group
N	46	45
ΣX	55	43
$\bar{X}$	1.19	.96
$\Sigma(X-\bar{X})^2$	495	268

The unbiased estimate of the variance was:

$$S^2 = \frac{\Sigma(X-\bar{X}_1)^2 - \Sigma(X-\bar{X}_2)^2}{N_1 + N_2 - 2}$$

$$= \frac{495 + 268}{89} = 8.35$$

The "t" ratio was

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S^2}{N_1} + \frac{S^2}{N_2}}} = \frac{.23}{.61} = .38$$

The number of degrees of freedom was 89. For a d.f. of 89 a "t" equal to 1.66 was required for significance at the .05 level using a one-tailed test.

It may be concluded that there was no justification for rejecting the null hypothesis. There was not a significant difference between the mean gain scores in spelling for the two groups.

TABLE XII

PROGRAMMED INSTRUCTION - EXPERIMENTAL GROUP
TOTAL LANGUAGE SCORE

Student No.	Possible	Pre Test 129	Post Test 129	Net Change	$(X-\bar{X})^2$
1		98	119	21	256
2		109	117	8	9
3		116	120	4	1
4		119	126	7	4
5		78	105	27	484
6		99	106	7	4
7		119	122	3	4
8		104	102	-2	49
9		98	102	4	1
10		88	99	11	36
11		114	118	4	1
12		87	93	6	1
13		102	98	-4	81
14		105	104	-1	36
15		107	113	6	1
16		102	97	-5	100
17		122	119	-3	64
18		98	75	-23	784
19		112	117	5	0
20		118	127	9	16
21		95	102	7	4
22		66	76	10	25
23		95	112	17	144
24		95	98	3	4
25		121	125	4	1
26		118	123	5	0

TABLE XII (continued)

Student No.	Possible	Pre Test 129	Post Test 129	Net Change	$(X-\bar{X})^2$
27		121	122	1	16
28		117	113	-4	81
29		116	120	4	1
30		94	105	11	36
31		93	105	12	49
32		95	91	-4	81
33		116	125	9	16
34		98	95	-3	64
35		109	110	1	16
36		114	116	2	9
37		118	118	0	25
38		89	93	4	1
39		114	121	7	4
40		105	123	18	169
41		111	112	1	16
42		113	122	9	16
43		103	116	13	64
44		101	108	7	4
45		113	114	1	16
46		73	92	19	196
			Total	238	2990

Mean Gain $\bar{X}$ = 5.02

TABLE XIII

PROGRAMMED INSTRUCTION - CONTROL GROUP
TOTAL LANGUAGE SCORE

Student No.	Possible	Pre Test 129	Post Test 129	Net Change	$(X-\bar{X})^2$
1		101	101	0	4
2		118	120	2	0
3		109	119	10	64
4		104	107	3	1
5		100	99	-1	9
6		88	91	3	1
7		110	113	3	1
8		98	107	91	49
9		89	87	-2	16
10		117	125	8	36
11		123	121	-2	16
12		117	115	-2	16
13		113	117	4	4
14		114	103	-11	169
15		100	107	9	49
16		112	117	5	9
17		98	92	-6	64
18		107	113	6	16
19		110	99	-11	169
20		106	121	15	169
21		93	91	-2	4
22		114	106	-8	100
23		105	110	5	9
24		119	119	0	4
25		104	101	-3	25
26		111	112	1	1

TABLE XIII (continued)

Student No.	Possible	Pre Test 129	Post Test 129	Net Change	$(X-\bar{X})^2$
27		115	123	8	36
28		89	87	-2	16
29		106	99	-7	81
30		90	97	7	25
31		96	83	-13	225
32		117	119	2	0
33		94	93	-1	9
34		103	106	3	1
35		119	120	1	1
36		98	93	-5	49
37		95	104	9	49
38		90	92	2	0
39		117	119	2	0
40		89	94	5	9
41		118	115	-3	25
42		89	108	19	289
43		102	107	5	9
44		81	93	12	100
45		85	85	0	4
		Total		79	1933
		Mean Gain $\bar{X}$ = 1.76			

Data Treatment - Entire Language Test

	Experimental Group	Control Group
N	46	45
ΣX	238	79
$\bar{X}$	5.02	1.76
$\Sigma(X-\bar{X})^2$	2990	1933

The unbiased estimate of the variance was:

$$S^2 = \frac{\Sigma(X-\bar{X}_1)^2 + \Sigma(X-\bar{X}_2)^2}{N_1 + N_2 - 2} = \frac{2990 + 1933}{89}$$

$$= 55.3$$

The ratio "t" was

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S^2}{N_1} + \frac{S^2}{N_2}}} = \frac{5.02 - 1.76}{\sqrt{\frac{55.3}{46} + \frac{55.3}{45}}}$$

$$= \frac{3.26}{1.55} = 2.10$$

The number of degrees of freedom was 89. For 89 d.f. a "t" equal to 1.66 was required for significance at the .05 level using a one-tailed test.

It may be concluded that there was justification for null hypothesis. There was a significant difference between the mean gain scores in language for the two groups.

Comparison of I.Q. and Gain Score

Tables XIV and XV provided the source of data for comparing the more intelligent half of the experimental group with the more intelligent half of the control group. Mean gain scores in each case were used as a basis for the t-tests recorded on the page following Table XV. In a like manner the less intelligent half of the experimental group was compared with the less intelligent half of the control group. This comparison is described on the second page following Table XV.

Table XVI provided data for calculating the Pearson Product-moment coefficient between I.Q. and gain score for the experimental group.

Table XVII provided necessary data for the calculation of Spearman's coefficient of rank correlation between I.Q. and mean gain score for the experimental group.

In Table XVIII mean gain scores for each of the groups were referred to the California Grade Placement Table and increases in grade placement compared.

TABLE XIV

I.Q., GAIN SCORE AND SQUARED DEVIATIONS FOR EXPERIMENTAL GROUP

Student No.	I.Q.	Gain Score	$(X-\bar{X})^2$
41	139	1	9
27	134	1	9
32	130	-4	64
9	127	4	0
37	126	0	16
45	126	1	9
25	125	4	0
26	125	+5	1
36	123	2	4
29	123	4	0
28	121	-4	64
16	121	-5	81
4	120	7	9
6	120	7	9
17	120	-3	49
7	120	3	1
10	118	11	49
19	118	5	1
20	118	9	25
40	118	18	256
11	116	4	0
5	112	27	529
34	113	-3	49
Sub Total		94	1234

TABLE XIV (continued)

Student No.	I.Q.	Gain Score	$(X-\bar{X})^2$
21	111	7	16
44	111	7	16
3	110	4	1
46	110	19	256
39	109	7	16
1	108	21	324
42	107	9	36
43	106	13	100
35	106	1	4
33	106	9	36
2	106	8	25
31	105	12	81
14	104	-1	16
38	102	4	1
30	101	11	64
18	101	-23	676
13	99	-4	49
12	98	6	9
15	98	6	9
23	95	17	256
8	94	-2	25
22	90	10	49
24	84	3	0
Sub Total		144	2065
Total		238	3299

TABLE XV

I.Q., GAIN SCORE AND SQUARED DEVIATIONS FOR CONTROL GROUP

Student No	I.Q.	Gain Score	$(X-\bar{X})^2$
2	145	2	1
35	144	1	4
11	136	-2	25
16	131	5	4
42	129	19	256
32	129	2	1
20	128	15	144
13	128	4	1
10	128	8	25
12	127	-2	25
18	126	6	9
15	126	9	36
5	125	-1	16
9	125	-2	25
26	125	1	4
27	125	8	25
28	125	-2	25
39	124	2	1
41	122	-3	36
34	120	3	0
14	118	-11	196
3	116	10	49
21	115	-2	25
Sub Total		70	933

TABLE XV (continued)

Student No	I.Q.	Gain Score	$(X-\bar{X})^2$
24	114	0	0
30	112	7	42
1	112	0	0
25	111	-3	12
43	111	5	20
22	110	-8	72
29	109	-7	56
33	109	-1	2
37	109	9	72
23	107	5	20
17	106	-6	42
6	106	3	6
4	105	3	6
40	104	5	20
45	101	0	0
44	100	12	132
36	99	-5	30
38	91	2	2
8	96	9	72
19	95	-11	132
7	92	3	6
31	90	-13	182
Sub Total		9	926
Total		79	1859

Treatment of Scores of Students having an I.Q. above the Median for their Group

	Experimental Group	Control Group
N	23	23
ΣX	94	70
X	4.09	3.04
$\Sigma(X-\bar{X})^2$	1234	933

The unbiased estimate of the variance was:

$$s^2 = \frac{\Sigma(X-\bar{X}_1)^2 + \Sigma(X-\bar{X}_2)^2}{N_1 + N_2 - 2} = \frac{1234 + 933}{44}$$

$$= 49.5$$

The ratio "t" was

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S^2}{N_1} + \frac{S^2}{N_2}}} = \frac{4.09 - 3.04}{\sqrt{\frac{49.5}{23} + \frac{49.5}{23}}}$$

$$t = \frac{1.05}{2.07} = .51$$

The number of degrees of freedom was 44. For 44 d.f. a "t" equal to 1.68 was required for significance at the .05 level using a one-tailed test. In this case the null hypothesis was upheld. There was no significant difference between the mean gain scores in language for the two groups.

Comparison of Scores of Students having an I.Q. below the Median for their Group

	Experimental Group	Control Group
N	23	22
$\sum X$	144	9
$\bar{X}$	6.26	.41
$\sum (X-\bar{X})^2$	2065	926

The unbiased estimate of the variance was:

$$S^2 = \frac{\sum (X-\bar{X}_1) + \sum (X-\bar{X}_2)^2}{N_1 + N_2 - 2} = \frac{2065 + 926}{43}$$

$$= 69.6$$

The ratio "t" was

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S^2}{N_1} + \frac{S^2}{N_2}}} = \frac{6.26 - .41}{\sqrt{\frac{69.6}{23} + \frac{69.6}{22}}}$$

$$= 2.38$$

The number of degrees of freedom was 43. For 43 d.f. a "t" equal to 1.68 was required for significance at the .05 level using a one-tailed test. In this case the null hypothesis was rejected. There was a significant difference between mean gain scores for the two groups.

TABLE XVI

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENT DATA FOR EXPERIMENTAL GROUP

No.	X Gain Score	Y I.Q.	x	y	x^2	y^2	xy
1	21	108	16	-4.5	256	20	-72
2	8	106	3	-6.5	9	42	-18
3	4	110	-1	-2.5	1	6	2
4	7	120	2	7.5	4	56	15
5	27	113	22	.5	484	0	11
6	7	120	2	7.5	4	56	15
7	3	120	-2	7.5	4	56	-15
8	-2	94	-7	-18.5	49	342	129
9	4	127	-1	14.5	1	210	-14
10	11	118	6	5.5	36	30	33
11	4	116	-1	3.5	1	12	-4
12	6	98	1	-14.5	1	210	-14
13	-4	99	-9	-13.5	81	182	122
14	-1	104	-6	-8.5	36	72	51
15	6	98	1	-14.5	1	210	-14
16	-5	121	-10	8.5	100	72	-85
17	-3	120	-8	7.5	64	56	-60
18	-23	101	-28	-11.5	784	132	322
19	5	118	0	5.5	0	30	0
20	9	118	4	5.5	16	30	22
21	7	111	2	-1.5	4	2	-3
22	10	90	3	-22.5	9	506	-67
23	17	95	12	-17.5	144	306	-210
24	3	84	-2	-28.5	4	812	57
25	4	125	-1	12.5	1	156	-12
26	5	125	0	12.5	0	156	0

TABLE XVI (continued)

No.	X Gain Score	Y I.Q.	x	y	x^2	y^2	xy
27	1	134	-4	21.5	16	462	-86
28	-4	121	-9	8.5	81	72	-76
29	4	123	-1	10.5	1	110	-10
30	11	101	6	-11.5	36	132	-69
31	12	105	7	-7.5	49	56	-53
32	-4	130	-9	17.5	81	306	-158
33	9	106	4	-6.5	16	42	-26
34	-3	112	-8	- .5	64	0	4
35	1	106	-4	-6.5	16	42	26
36	2	123	-3	10.5	9	110	-31
37	0	126	-5	13.5	25	182	-67
38	4	102	-1	-10.5	1	110	10
39	7	109	2	-3.5	4	12	-7
40	18	118	13	+3.5	169	30	72
41	1	139	-4	26.5	16	702	-106
42	9	107	4	-5.5	16	30	-22
43	13	106	8	-6.5	64	42	-52
44	7	111	2	-1.5	4	2	-3
45	1	126	-4	13.5	16	182	-54
46	19	110	14	-2.5	196	6	-35
	5.02	112.48			2974	6392	-552
	$\bar{X}$	$\bar{Y}$			Σx^2	Σy^2	Σxy

<u>The Pearson Product Moment Correlation Coefficient Comparing Mean Gain Score and I.Q.</u>

Experimental Group

N = 46

Mean Gain Score $\bar{X}$ = 5.02

Mean I.Q. $\bar{Y}$ = 112.48

Deviation Scores:

$$\Sigma x^2 = 2974$$

$$\Sigma y^2 = 6392$$

$$\Sigma xy = 552$$

$$S_x = \sqrt{\frac{\Sigma x^2}{N}} = \sqrt{\frac{2974}{46}} = 8.08$$

$$S_y = \sqrt{\frac{\Sigma y^2}{N}} = \sqrt{\frac{6392}{46}} = 11.73$$

$$\text{PPM Coefficient } r = \frac{\Sigma xy}{NS_xS_y} = \frac{-552}{46 \times 8.08 \times 11.73}$$

$$= -.12$$

This negative correlation coefficient may be explained by the ceiling effect which results from the high performance of the more intelligent group on the pre-test. Since many of these achieved close to a maximum score to begin with they did not have nearly as much room for improvement as those who obtained a low score on the pre-test.

TABLE XVII

SPEARMAN'S COEFFICIENT OF RANK CORRELATION DATA FOR EXPERIMENTAL GROUP

No.	Rank Gain Score X	Rank I.Q. Y	d	d^2
1	2	29	-27	729
2	14	32.5	$-18\frac{1}{2}$	342
3	$26\frac{1}{2}$	26.5	0	0
4	17	14.5	$3\frac{1}{2}$	12
5	1	23	22	484
6	17	14.5	$2\frac{1}{2}$	6
7	$30\frac{1}{2}$	14.5	16	256
8	39	44	-5	25
9	$26\frac{1}{2}$	4	$22\frac{1}{2}$	506
10	$8\frac{1}{2}$	18.5	-10	100
11	$26\frac{1}{2}$	21	$5\frac{1}{2}$	30
12	$20\frac{1}{2}$	41.5	-21	441
13	42	40	2	4
14	38	36	2	4
15	$20\frac{1}{2}$	41.5	-21	441
16	45	11.5	$34\frac{1}{2}$	1190
17	$40\frac{1}{2}$	14.5	26	676
18	46	38.5	$5\frac{1}{2}$	30
19	$22\frac{1}{2}$	18.5	4	16
20	12	18.5	$-5\frac{1}{2}$	30
21	17	24.5	$-7\frac{1}{2}$	56
22	10	45	-35	1225
23	5	43	-38	1444
24	$30\frac{1}{2}$	46	$-15\frac{1}{2}$	240
25	$26\frac{1}{2}$	7.5	19	361
26	$22\frac{1}{2}$	7.5	15	225

TABLE XVII (continued)

No.	Rank Gain Score X	Rank I.Q. Y	d	d^2
27	$34\frac{1}{2}$	2	$32\frac{1}{2}$	1056
28	42	11.5	$30\frac{1}{2}$	930
29	$26\frac{1}{2}$	9.5	17	289
30	$8\frac{1}{2}$	35	$-26\frac{1}{2}$	702
31	7	38.5	$-31\frac{1}{2}$	992
32	42	3	39	1521
33	12	32.5	$20\frac{1}{2}$	420
34	$40\frac{1}{2}$	22	$22\frac{1}{2}$	506
35	$34\frac{1}{2}$	32.5	2	4
36	32	9.5	$22\frac{1}{2}$	506
37	37	5.5	$31\frac{1}{2}$	992
38	$26\frac{1}{2}$	37	$10\frac{1}{2}$	110
39	17	28	11	121
40	4	18.5	$14\frac{1}{2}$	210
41	$34\frac{1}{2}$	1	$33\frac{1}{2}$	1122
42	12	30	18	324
43	6	32.5	$26\frac{1}{2}$	702
44	17	24.5	$7\frac{1}{2}$	56
45	$34\frac{1}{2}$	5.5	29	841
46	3	26.5	$23\frac{1}{2}$	552
			Σd^2	= 20,829

<u>Comparison of Gain Score and I.Q. using Spearman's Coefficient of Rank Correlation</u>

<u>Experimental Group</u>

$$N = 46$$

$$\rho = 1 - \frac{6 \sum d^2}{N \ (N^2 - 1}$$

$$= 1 - \frac{6 \ (20,829)}{46 \ (2115)}$$

$$= 1 - \frac{124,974}{97,290}$$

$$= - .28$$

<u>Testing the Significance of Spearman's ρ</u>

When n = 10 or greater we may test the significance of ρ using a "t" test involving the formula:

$$t = \rho \sqrt{\frac{N - 2}{1 - \rho^2}}$$

This quantity has a t distribution with N-2 degrees of freedom.

In this case we found that

$$t = -.28 \sqrt{\frac{44}{1 - .0784}}$$

$$t = -.28 \sqrt{\frac{44}{.9216}}$$

$$t = -.28 \sqrt{47.73}$$

$$= -.28 \ (-6.91)$$

$$= 1.93$$

For N-2 or 44 degrees of freedom the value of "t" required for significance at the .05 level on a two-tailed test is 2.01. Since the value 1.93 fell somewhat short of that it was concluded that the negative correlation between gain score and I.Q. was not statistically significant.

TABLE XVIII

ANALYSIS OF GAIN SCORE IN TERMS OF GRADE PLACEMENT NORMS (CALIFORNIA ACHIEVEMENT TEST)

	Experimental Group	Control Group
Average Score (Pre-test)	104.30 (104)	103.84 (104)
Average Gain Score	5.02	1.76
Average Score (Post-test)	109.32 (109)	105.60 (106)
Increase in Grade Placement	9.6 to 10.2	9.6 to 9.8
Net increase in Grade Placement	6 months	2 months.

CHAPTER V

CONCLUSIONS, RECOMMENDATIONS AND SUMMARY

Throughout this study an effort has been made to maintain objectivity, consequently, the opinions of neither students nor teachers were recorded. Instead, an attempt was made to measure, in behavioural terms, changes which have taken place in the experimental subjects. Moreover, these changes were analysed to determine their significance. From this analysis certain conclusions and recommendations evolve.

I. CONCLUSIONS

A Review of the Findings

This study was concerned mainly with testing the hypothesis that growth in language achievement is independent of the use of a programmed language text-book as an adjunct to the regular language program. This hypothesis has been tested in connection with all four language areas measured by the California Achievement Test, viz., capitalization, punctuation, word usage and spelling. In each case the null hypothesis is assumed, $U_1 = U_2$ or that no difference exists between the population means with regard to gain score. The results are summarized below:

(a) Capitalization

When experimental and control groups were compared on this test, a "t" ratio of 2.94 was obtained. This compared to a critical "t" of 1.66 indicated that there was a highly significant difference between the two groups and the null hypothesis was rejected.

(b) Punctuation

In this language area a "t" ratio of .63 was obtained. Since this was less than the critical value of 1.66, the null hypothesis was upheld.

(c) Word Usage

Here it was again justifiable to reject the null hypothesis since the "t" score obtained was 1.9.

(d) Spelling

A comparison of the two groups in spelling provided no justification for rejecting the null hypothesis since the "t" value obtained was .38.

(e) Total Test

An analysis of the results on the total test indicated a significant difference between the two groups since a value of 2.10 was obtained for "t". Thus the null hypothesis was justifiably rejected.

(f) Gain Scores of Students having high I.Q.

In this portion of the study, each group, experimental and control, was divided in two on the basis of I.Q. The upper half of the experimental group was compared with the upper half of the control group.

In this comparison a "t" value of .51 was obtained indicating no significant difference in gain score.

(g) Gain Scores of Students having low I.Q.

A similar comparison was made between the lower half of the experimental group with the lower half of the control group. In this case a "t" value of 2.38 was obtained indicating that the difference between groups was significant.

(h) Pearson Product-Moment Coefficient

For the experimental group only, a Pearson product-moment correlation coefficient was obtained comparing the variables, gain score and I.Q. The value of this coefficient was observed to be -.12, not large enough for significance at the .05 level.

(i) Spearman's Coefficient

A second comparison of mean gain score and I.Q. for the experimental group was determined using Spearman's Coefficient of Rank Correlation. The value of ρ was -.28. Again we found a negative correlation between mean gain score and I.Q. When this value of ρ was subjected to a "t" test however, it was found to be not significant at the .05 level.

The negative correlation between mean gain score and I.Q. obtained in the last two tests described above raises a question. Is this an indication that students with a low I.Q. tend to learn more effectively through programmed instruction than do students of higher I.Q.? I suggest that this conclusion should not be drawn

from the above data.

Instead, the explanation could very well lie in the "ceiling effect" produced by high scores of students on the pre-test. As an example, let us look at some scores of those students with highest I.Q. On the four sections of the pre-test the two students having the highest I.Q.'s in the entire group scored as follows:

	Capitalization	Punctuation	Usage	Spelling
Possible Score	30	29	40	30
Top Student's Score	29	26	38	25
Second Student's Score	29	26	38	26

It can be seen that those students who obtained scores near the maximum on the pre-test could not possibly have shown a large gain score. Similarly, those who did poorly on the pre-test had a good deal of room for improvement.

It is the writer's belief that this "ceiling effect" was the reason for the negative correlations obtained when Pearson's and Spearman's coefficients were calculated. In any case, these indices were not large enough to be statistically significant.

Implications for the Administrator

It would appear that programmed instruction is here to stay. From both the survey of literature and the results of this experiment, it may be concluded that the child does learn by this method. Moreover,

the learning can be shown to be significant in degree. This is a rather basic conclusion. It means that the busy teacher may, through the preparation and use of programs, provide a more individualistic type of instruction for her pupils. It also means that programmed instruction may eventually assist in providing the basic data for a new theory of teaching - the counterpart of the theory of learning. It is hoped that this type of instruction may act as a controlling device to eliminate the effects of extraneous variables and their interrelationships. Programming may well assist in providing us with the educational laboratory. We are all aware of the tremendous advances which have been made in the chemists' and the physicists' laboratories in recent years. Programmed instruction should now be considered as one method by means of which controlled laboratory conditions may be approached. Obviously, an experiment involving human learning presents entirely different problems from those involved in a chemistry or physics experiment. Yet, if through this means certain variables are manipulated in a rigorous way and certain conditions are standardized, a large step towards a science of instruction will have been taken.

Many writers in the field of educational psychology consider that programmed instruction constitutes a major break-through in educational research. Much exploration is still required to measure its potentiality and to devise the most effective and efficient means of using it. Also, through such studies it will be possible to under-

stand the optimum conditions for its use.

The familiar mass media certainly do communicate effectively but they do not control; they might be referred to as "open loop" systems. For rapid modification of the learner's behaviour they lack the essential feedback ingredient. By contrast, the program is a "closed loop" system which does provide feedback.

Advocates of programmed instruction and teaching machines maintain that one of the most serious criticisms of to-day's classroom is the relative infrequency of re-inforcement. It is pointed out that many students are dependent upon one teacher for knowledge of results; consequently, the total number of opportunities for the teacher to reinforce knowledge is quite limited. An example of one place where these inefficiencies reveal themselves is in the drill subjects such as arithmetic. The consequence is that many children fail to learn arithmetic quickly and never do achieve a high level of confidence in their knowledge or skill.

A comparison has been made between the motion picture and a program. In an educational film neither the rate of presentation nor the amount of repetition is varied to suit the needs of the individual learner; the motion picture is not adaptive. A particular film may present material too rapidly for one student but too slowly for the next. The same could be said for school broadcasts by radio or television.

Programmed instruction also requires a high degree of activity on the part of the learner. It puts considerably more emphasis upon

reward than upon blame as a motivational force. The program also provides versatility in that it can be largely factual or it can be thought-provoking; it can include logic or rote learning.

One other point should be of interest to the educator who is concerned with the problem of ignorance in the world. Programmed instruction can very readily be adapted from one society to another regardless of the differences in language, race, religion, creed, wealth or locale. Moreover, a program has an equal amount of patience with the fast and the slow learner. Likewise it can be considered the democratic leveller since it is equally effective with the rich and the poor. It is quite possible that some learning may be available to many persons who for economic reasons would be denied other educational opportunities.

Implications for the Teacher

Programmed instruction is a device not for eliminating the teacher, but rather for increasing his effectiveness. It should take much of the dredgery from teaching; although the teacher is still the planner and the organizer of instruction he is no longer bound to the wearying details of instruction and drill. Thus the teacher may spend more time in determining and meeting individual needs. He is able to devise more efficient methods of instruction and keep the content of his courses up to date. More time will be at his disposal so that he may have a better knowledge of his subject matter and of the individual problems of his students.

II. RECOMMENDATIONS

In the light of the results of this study, it is recommended that programmed instruction is worthy of investigation by every teacher and every administrator. This technique provides a systematic method whereby the teacher can conduct his own research - as simple or as sophisticated as he wishes to make it. The purchase of expensive and cumbersome machines is certainly not necessary; an ordinary book programmed vertically or horizontally will do just as well. The scrambled book, although requiring a bit more planning, may be readily constructed by the classroom teacher. A study was made by Feldhusen and Birt to compare various methods of presenting programmed material.[1] Included in this experiment were programmed books as well as teaching machines. The hypothesis that no difference existed between results achieved by experimental groups was upheld. We may conclude from this finding that the research done by the classroom teacher with book-type devices is as valid as that performed with more elaborate equipment.

The educator will also be interested in certain suggestions as to how to construct a program. Evans Glasser and Homme have provided

---

[1] J. F. Feldhusen and A. Birt, "A Study of Nine Methods of Presentation of Programmed Learning Material," The Journal of Educational Research, Vol. 55, No. 9, June-July 1962, pp. 461-466.

a number of suggestions for the neophyte program builder.[2]

First, the research presently available shows no significant difference in learning between those who respond explicitly from those who respond implicitly. In fact there is a saving in time when the implicit response is used. Thus by using implicit responding many more frames may be completed in a specified length of time.

If, however, the teacher wishes to keep a record of student responses for purposes of revision and improvement of the program, there obviously must be a written response. Evans, Glasser and Homme have concluded that in the developmental phase of a program, overt responses are definitely necessary. After the program has been shown to produce certain criterion behaviour, it may then be desirable to require recorded responses to some items and implicit responses to others. If it were found that such a practice resulted in no performance decrements a considerable saving in completion time for the student would be effected. Moreover, fewer recorded responses require less writing space and simplify the entire auto-instructional device.

Another result described by the same authors is a slight preference for the constructed response made over the multiple choice mode.

---

[2]J. L. Evans, R. Glasser and L. E. Homme, "An Investigation of 'Teaching Machine' Variables Using Learning Problems in Symbolic Logic," The Journal of Educational Research, Vol. 55, No. 9, June-July 1962, pp. 433-439.

This verifies Skinner's contention. Although a considerable difference in performance on these two response modes was observed, this difference was found to be not statistically significant.

Possibly the teacher who is about to write his first program would be well advised to consider the full basic principles as described by Fry[3].

These are:

(1) The Principle of Short Steps.

(2) The Principle of Active Responding.

(3) The Principle of Immediate Confirmation.

(4) The Principle of Self Pacing.

(5) The Principle of Student Testing.

III. SUMMARY

An entire class of 91 Grade VIII students in Fort Saskatchewan Junior High School was divided into two groups on a basis of random selection. All students were tested using the California Achievement Test in Language, Junior High Level 1957 edition, Form W. During a six-week period the experimental group of 46 students worked through the programmed textbook, English 2600 by Blumenthal. While the experimental group was so engaged, the control group worked at

---

[3]E. B. Fry, Teaching Machines and Programmed Instruction, (New York: McGraw Hill Book Co., 1963), pp. 208-220.

unrelated assignments. At the end of the six weeks an alternate form of the California Achievement Test was administered. The scores on the two tests for each student were compared and a gain score computed. Average gain score for the experimental group was compared to average gain score for the control group.

Thus a treatment had been applied to one group and not to the other; it was questioned whether this treatment had resulted in significant differences in gain score. The significance of these differences was established through the application of the t-test. When this was done it was found that the difference in gain scores between the experimental and control group was significant at the .05 level.

When the t-test of significance was applied to the sub-sections of language learning, it was found that there had been a significant degree of improvement in the areas of capitalization and word usage but not in punctuation nor in spelling.

The above results may partially be explained if the testing instrument is examined. The language test used had 129 items - a sufficient number to offset minor variations of performance on the sub-tests and yield quite a reliable result. The sub-test on punctuation had the fewest items, viz., 29. This number of items may not have been sufficient to provide reliable data for statistical treatment. This could explain the fact that on this sub-test there was no significant increase in gain score while on capitalization (30 items) and

word usage (40 items) there was. Although a large degree of reliability may not safely be attributed to sub-test scores, the composite score for each student would appear to be quite reliable.

In regard to the fourth sub-test, spelling, there was a very small difference in gain score between the two groups which proved not to be significant. This result might have been expected since the English 2600 program contained no spelling instruction.

In addition to the above, a correlation between I.Q. and gain score was calculated for the experimental group. The Pearson product-moment correlation coefficient obtained was -.12 while Spearman's coefficient of rank correlation was -.28. Neither coefficient was significant at the .05 level.

Finally, the mean gain scores for each of the student groups were referred back to the California Achievement Test Grade Placement Table. On this table the experimental group which had had additional instruction time, (2-1/2 hours per week) advanced six months in grade placement. The control group, which had spent only the standard amount of time in regular language classes, 4 hours per week, advanced an expected two months on this table.

Thus it may be concluded that students can raise their standard of achievement on a language test by working through a programmed language text. Moreover, the degree of improvement is somewhat proportional to the amount of time spent on the program.

BIBLIOGRAPHY

BIBLIOGRAPHY

A. BOOKS

Bloom, B. F., Editor: A Taxonomy of Educational Objectives, Handbook I, Cognitive Domain, New York: Longman's Green, 1956.

Blumenthal, Joseph C., English 2600, New York: Harcourt Brace and World Inc., 1960.

Deterline, W. A., An Introduction to Programmed Instruction. Englewood Cliffs, N. J.: Prentice Hall, 1962.

Dixon, W. J., and F. J. Massey, Introduction to Statistical Analysis. New York: McGraw Hill Book Co., 1957.

Epstein, S., and B. Epstein, The First Book of Teaching Machines, New York: Franklin Worts Inc., 1961.

Ferguson, G. A., Statistical Analysis in Psychology and Education. New York: McGraw Hill, 1959.

Fine, B., Teaching Machines. New York: Sterling Publishing Co. Inc., 1962.

Folitz, Charles I., The World of Teaching Machines. Washington, D.C.: Electronic Teaching Laboratories, 1961.

Fry, E. B., Teaching Machines and Programmed Instruction. New York: McGraw Hill Book Co., 1963.

Gagne, Robert M., and Robert C. Boles, "A Review of Factors in Learning Efficiency," Automatic Teaching: the State of the Art. E. Galanter, Editor, New York: John Wiley and Sons, 1959.

Galanter, E. H. Editor: Automatic Teaching: the State of the Art. New York: John Wiley and Sons, 1959.

Green, Edward J., The Learning Process and Programmed Instruction. New York: Holt Rinehart and Wilson, 1962.

Lambert, P., Editor: The Teacher and the Machine. Madison, Wis.: Dembar Educational Research Services, 1962.

Lumsdaine, A. A., and R. Glaser, Teaching Machines and Programmed Learning: A Source Book. Washington, D.C.: NEA 1960.

Lysaught, J. P., and C. M. Williams, A Guide to Programmed Instruction. New York: John Wiley and Sons, 1963.

Mager, R. F., Preparing Objectives for Programmed Instruction. San Francisco: Fearon Publishers, 1961.

Margulies, S., and L. D. Eiger, Applied Programmed Instruction. New York: John Wiley and Sons, 1962.

Markle, S. M., A Programmed Primer on Programming. New York: The Centre for Programmed Instruction 1961.

McNemar, Q., Psychological Statistics. New York: John Wiley and Sons, 1955.

Milton, O., and L. J. West, Programmed Instruction and How It Works. New York: Harcourt Brace and World Inc., 1961.

Pask, G., "Adaptive Teaching and Adaptive Machines." Teaching Machines and Programmed Learning: A Source Book. Lumsdaine and Glaser, Editors. Washington, D.C.: NEA, 1960.

Rath, G. J., N. S. Anderson, and R. C. Brainerd, "The I.B.M. Research Centre Teaching Machine Project," Automatic Teaching: the State of the Art. Galanter, E., Editor, New York: John Wiley and Sons, 1959.

Reed, J. E., and J. L. Hayman, "An Experiment Involving Use of English 2600, An Automated Instruction Text." The Teacher and the Machine. Lambert, P., Editor, Madison, Wis.: Dembar Educational Research Services, 1962.

Smith, W. I., and J. W. Moore, Editors. Programmed Learning, Theory and Research. Princeton, N.J., D. Van Nostrand Co., 1962.

Stolurow, L. M., Teaching by Machine. Washington: U.S. Government Printing Office, 1961.

B. PERIODICALS

Anderson, K. E., and A. J. Edwards, "The Educational Process and Programmed Instruction," The Journal of Educational Research. Vol. 55, No. 9, August, 1962, pp. 537-543.

Barcus, D., J. L. Hayman, and J. T. Johnston, "Programming Instruction in Elementary Spanish," Phi Delta Kappan. Vol. 44, No. 6, March 1963, pp. 269-272.

Beck, C. E., "Teacher Education Self Taught," The Journal of Teacher Education. Vol. 14, No. 1, March, 1963.

Broudy, H. S., "Socrates and the Teaching Machine," Phi Delta Kappan, Vol. 44, No. 6, March, 1963, pp. 243-246.

Bushnell, D.D., "Computer-based Teaching Machines," Journal of Educational Research, Vol. 55, No. 9 June-July 1962, pp. 528-531.

Crowder, N. A., "On the Differences Between Linear and Intrinsic Programming," Phi Delta Kappan, Vol. 44, No. 6, March 1963, pp. 250-254.

Eigen, L. D., "A Comparison of Three Modes of Presenting a Programmed Instruction Sequence," The Journal of Educational Research, Vol. 55, No. 9, June-July, 1962, pp. 453-460.

Eigen, L. D., "High School Student Reactions to Programmed Instruction." Phi Delta Kappan, Vol. 44, No. 6, March 1963, pp. 282-285.

Evans, J. L., R. Glaser, and Homme, "An Investigation of Teaching Machine Variables Using Learning Programs in Symbolic Logic." The Journal of Educational Research, Vol. 55, No. 9, June-July 1962, pp. 433-451.

Fattu, N. A., "Evaluation of Programmed Instruction," Education. Vol. 83, No. 7, March 1963, pp. 406-411.

Feldhusen, J. T., and A. Birt, "A Study of Nine Methods of Presentation of Programmed Learning Material," The Journal of Educational Research, Vol. 55, No. 9, June-July, 1962, pp. 461-466.

Forbes, J. E., "Programmed Instructional Materials - Past, Present, Future." The Mathematics Teacher, Vol. 56, No. 4, April 1963, pp. 224-227.

Hough, J. B., "An Analysis of the Efficiency and Effectiveness of Selected Aspects of Machine Instruction," The Journal of Educational Research, Vol. 55, No. 9, June-July 1962, pp. 467-471.

Hough, John B., and R. Revsin, "Programmed Instruction at the College Level: A Study of Several Factors Affecting Learning," Phi Delta Kappan, Vol. 44, No. 6, March, 1963.

Komoski, P. K., "Programmed Instruction-a Prologue to What?" Phi Delta Kappan, Vol. 44, No. 6, March 1963, pp. 292-295.

Kumboltz, J. D., and B. Bonawitz, "The Effect of Receiving and Confirming Response in Context in Programmed Material," Journal of Educational Research, Vol. 55, No. 9, June-July 1962, pp. 472-475.

Kumboltz, J. D., and R. G. Weisman, "The Effect of Intermittent Confirmation in Programmed Instruction," Journal of Educational Psychology. Vol. 53, No. 6, December 1962. pp. 250-253.

Lambert, P., D. M. Miller and D. E. Wiley, "Experimental Folklore and Experimentation: the Study of Programmed Learning in the Wauwatosa Public Schools," Journal of Educational Research, Vol. 55, No. 9, June-July 1962, pp. 485-491.

Lawson, C.A., "Construction and Evaluation of Programmed Materials in Biology," The American Biology Teacher. Vol. 25, No. 3, March 1963, pp. 209-211.

Levine, J., "Lets Debate Programmed Reading Instruction." The Reading Teacher, Vol. 16, No. 5, March 1963, pp. 337-340.

Mayhew, D. J., and A. F. Johnson, "Teaching Machines," Journal of Engineering Education. 50: No. 1, 51-52, 1959.

McDonald, F. J., and D. W. Allan, "An Investigation of Presentation, Response and Corrective Factors in Programmed Instruction," Journal of Educational Research, Vol. 55, No. 9, June-July 1962, pp. 502-507.

Pressey, S. L., "Development and Appraisal of Devices Providing Immediate Automatic Scoring of Objective Tests and Concomitant Self-instruction," Journal of Psychology, Vol. 29, April 1950.

Rugel, P., "Programmed Learning and Reading," Elementary English, Vol. 40, No. 3, March 1963, pp. 251-254.

Roe, A., "A Comparison of Branching Methods for Programmed Learning," Journal of Educational Research, Vol. 55, No. 9, June-July 1962, pp. 407-416.

Silberman, H. T., "Self-Teaching Devices and Programmed Materials," Review of Educational Research, Vol. 32, No. 2, April 1962, pp. 178-189.

Silvern, L., "Some Thoughts on Programmed Learning," Overview, Vol. 4, No. 4, April 1963, pp. 35-36.

Skinner, B. F., "The Science of Learning and the Art of Teaching," Harvard Educational Review, Vol. 24, No. 2, 1954.

Stake, R. E., "The Teaching Machine: Tool of the Future or Passing Fancy?" Phi Delta Kappan, Vol. 44, No. 6, March 1963. pp. 243-246.

Staturow, L. M., "Implications of Current Research and Future Trends," Journal of Educational Research, Vol. 55, No. 9, June-July 1962, pp. 519-527.

Staturow, L. M., "Let's be Informed on Programmed Instruction," Phi Delta Kappan, Vol. 44, No. 6, March 1963, pp. 255-257.

Staturow, L. M., and C. C. Walker, "A Comparison of Overt and Covert Responses in Programmed Learning," The Journal of Educational Research. Vol. 55, No. 9, June-July 1962, pp. 421-429.

Stott, D. H., "Genesis of Programmed Reading," Times Educational Supplement, No. 2492, Feb. 22, 1963, p. 354.

Wendt, P. R., and C. R. Grosvenor, "Programmed Instruction for Transfer to the Real Life Situation," Phi Delta Kappan. Vol. 44, No. 6, March 1963, pp. 273-277.

Wendt, P. R., and G. Rust, "Pictorial and Performance Frames in Branching Programmed Instruction," Journal of Educational Research, Vol. 55, No. 9, June-July 1962, pp. 430-432.

Wittrock, M. C., "Response Made in the Programming of Kinetic Molecular Theory Concepts," Journal of Educational Psychology, Vol. 54, No. 2, April, 1963.

Wohlwill, J. F., "The Teaching Machine: Psychology's New Hobby Horse," The Education Digest, Vol. 28, No. 6, February, 1963. pp. 5-8.

C. MISCELLANEOUS PUBLICATIONS

Mager, R. F., A Method for Preparing Auto-Instructional Programs. (Mimeographed).

Skinner, B. F., "Programming Verbal Knowledge for Automated Colleges," Paper read at Symposium on the Automation of Teaching. American Psychological Association Convention. Washington, D. C.: August, 1958.

Tiegs, E. W., and W. W. Clark, California Achievement Tests. Los Angeles: California Test Bureau, 1957.